FACTORS AFFECTING THE USE OF PRECAST CONCRETE SYSTEM IN SAUDI ARABIA

BY

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Dedicated

To

Dedicated to my Mother (Ehsan), my Father (Moussa) and my Family. For they have provided the support, love and affection, and without whom, none of my success would be possible.

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All praise is due only to ALLAH for his guidance and protection throughout the period of my study.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PCS	:	PCS
SA	:	SA

ABSTRACT

Full Name : [Ahmad Mousa Alfarra]

Thesis Title : [Factors Affecting The Use of Precast Concrete System in Saudi Arabia]

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The construction industry in Saudi Arabia (SA) is improving and getting larger day by day. Accordingly, new construction systems are entering the market to come over the disadvantages of other systems. The use of the precast concrete system (PCS) proposes numerous advantages such as speed in the construction, higher quality, environmentally friendly and lower cost in compare to other construction systems, which in line with KSA 2030 vision. There is a good opportunity for the precast system to get a big share in the market against the traditional construction systems i.e. cast in situ. These advantages could be the most important factors in choosing the PCS as a construction system. However, the aesthetic image of precast, limitation on the design of the precast system and the limitation of transporting the precast elements could affect the use of PCS negatively. In this thesis the factors affecting the use of PCS in SA has been studied, investigated and evaluated. These factors were explored through online surveys. The online questionnaires were sent via emails to 100 owners, 126 consultants, 126 contractors, and 50 precast manufacturers, that is 400 in total. 171 of the participants, many are holding high managerial positions such as CEO, COO, VP and senior managers, responded to the questionnaire. This makekes this research unique/significant and important to the construction industry. The results indicated that there are factors affecting the use of PCS positively such as demand for large

housing project, speed in the construction, higher quality, and lower cost, while other factors affecting the use negatively such as e aesthetic image of precast, limitation on the design of precast system and the limitation of transportation the precast elements. Different recommendations were proposed to enhance the use of PCS in SA, so the positive factors shall be kept and enhanced and to eliminate the factors that negatively affect the usage.

ملخص الرسالة

الاسم الكامل : أحمد موسى مهدي الفرا.

عنوان الرسالة : العوامل المؤثرة في استخدام أنظمة مباني الخرسانة المسبقة الصب.

التخصص : هندسة وإدارة الانشاءات.

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صناعة البناء والتشييد في المملكة العربية السعودية تعتبر من أكبر مجالات الصناعة. وقد دخلت منحى جديد هذه الأيام بعد التوجيهات الحكيمة و الروية الجديدة للمملكة رؤية-2030، والتي ترتكز في ترشيد الإنفاق والإنفاق الذكي وكذلك خلق فرص استثمارية جديدة .بناءً على هذا فإن صناعة البناء والتشييد بدأت تنظر وتتجه نحو أنظمة المباني الأكثر استدامة وصديقة للبيئة والأقل سعرا لتحل محل الأنظمة التقليدية و التي لها العديد من المساوىء. هنا تجد أنظمة الخرسانة المسبقة الصب فرصتها لما لها من مميزات مثل السرعة في البناء، والجودة العالية، الإستدامة، وصديقة للبيئة، وانخفاض التكلفة، والتي تتماشى مع رؤية المملكة-2030 . هذه المزايا هي أهم العوامل التي تؤثر في اختيار نظام الخرسانة الجاهزة كنظام للبناء. على رغم من أهمية هذه العوامل التي تؤثر ايجابا على استخدام هذا النظام ؛ إلا أنه هناك بعد العوامل التي تؤثر سلبا على استخدام نظام الخرسانة المسبقة الصب مثل صعوبة تنفيذ بعض الأشكال المعمارية باستخدام هذا النظام ، باللإضافة لمحدودية التصاميم التي يمكن عملها به و النقص في الخبرات وكذلك صعوبة نقل القطع الخرسانية. في هذه الأطروحة، تم دراسة العوامل المؤثرة على استخدام أنظمة الخرسانة الجاهزة في المملكة العربية السعودية، والتحقيق فيها وتقييمها. وقد تم استكشاف ذلك من خلال استطلاعات ارسلت عبر البريد الالكتروني إلى 100 مالك و 126 مكتب استشاري 126 مقاول و 50 مصنع للخرسانة الجاهزة المسبق الصنع ليبلغ عدد الإستبيانات التي ارسلت 400. وقد تم تلقي عدد كبير من الردود بلغ 171-رد، كثير منها لأشخاص يشغلون مناصب إدارية عالية مثل الرئيس التنفيذي، رئيس العمليات، نائب الرئيس وكبار المديرين. الشيء الذي يجعل هذا البحث فريدة من نوعها / وهام لصناعة البناء والتشييد. وتشير النتائج إلى أن هناك عوامل تؤثر على استخدام أنظمة الخرسانة المسبقة الصب بشكل إيجابي، في حين أن الآخر يؤثر على سلبا على الاستخدام.و قد تم اقتراح توصيات مختلفة لتعزيز استخدام أنظمة

الخرسانة المسبقة الصب ، لذلك يجب الحفاظ على العوامل الإيجابية وتعزيزها والقضاء على العوامل التي تؤثر سلبا على الاستخدام.

CHAPTER 1

INTRODUCTION

The construction industry in SA is improving and getting larger day by day. It was expected to grow by 20% during 2013, and it is the largest sector receiving investment in SA which is about USD 629 billion (Youssef, 2013). With this huge expansion and huge volume of the construction market, the demand of buildings is increasing. Accordingly, new construction systems were proposed in the market to come over the disadvantages of other systems as well to cover the huge demand of buildings. The PCS, which is considered as one type of the industrialized building systems (IBS), has been offered in the market (Badir, Kadir et al. 2002). There is a good opportunity for the precast system to get a big share of the market against the traditional construction system i.e. cast in situ. PCS offers several advantages, which support it to be commonly used in SA such as speed in the construction, higher quality, and lower cost compare to other traditional construction system. These advantages could be the most important factors in choosing the PCS as a construction system. However, the aesthetic image of precast, limitation on the design of precast system and the limitation of transportation the precast elements could affect the use of PCS negatively. So what are the factors that affect the choosing of the PCS as a construction system. In this thesis the Factors Affecting the Use of PCSs in SA has been studied, investigated and evaluated. Figure 1 shows an example of a precast concrete building.

Figure 1 Precast Concrete Building-LULU Hypermarket Dammam.

1.1 Problem Statement

With the huge expansion and huge volume of the construction market in SA, new construction systems were introduced to come over the disadvantages of other construction systems as well to cover the huge demand of buildings. The Kingdom 2030 vision that aims to manage KSA finances efficiently and effectively play a big role in directing the construction industry to select and use of new construction systems that are more economical, efficient and durable. The PCS, which is considered as one type of the

industrialized building systems (IBS), is one of these new systems (Badir, Kadir et al. 2002). Moreover, the PCS has different advantages such as speed in construction, high quality, lower cost, improve durability and sustainability. However, it is still not extensively used in SA; so this are the factors that are affecting the use of the PCS in SA?

1.2 Research Objectives

Due to lack of research in the field of PCS and its implementation difficulty in SA this research aims to:

1. Identify/Investigate the factors affecting the use of the PCS in SA.
2. Study these factors and their effect on the use of the PCS as a construction system.
3. Define the factors that have a positive/negative impact on the use of the PCS as construction system.
4. Provide recommendation to enhance the use of the PCS in SA.

1.3 Limitation of the Research

1. The results are limited to the buildings construction projects. Industrial constructions are not included.

1.4 Significance of this research

The construction industry in SA is booming these days, and more construction system becomes available to in the market to cover the huge demand of buildings. However, there are not enough research that study the implementation of these systems. Therefore, the importance of this study coming from the following:

1. Lack of researches conducted to study the implementation of the PCS in SA construction market.
2. This study Identifies/Investigates the factors affecting the use of the PCS in SA.
3. Knowing the affecting factors helps the owners, consultants, and contractors to select the best construction system, precast or others, that will match and suit their needs.
4. Considering the perception of the precast concrete manufacturers in the study is enhancing the understanding of the perfect use for the system. Also, it gives more precise idea about the strength of the PCS as a construction system.

1.5 The Outline

This thesis is divided into six main chapters that cover the topics, where it is structured as follows:

Chapter 1 Introduction:

The introduction provides an overview of the thesis, and provides a brief background about the PCS and some factors that affect the usage either positively or/and negatively. After that, it states the problem statement i.e. why it addresses the factors affecting the use of the PCS in SA as a topic. This chapter lists the research objectives in line with the project limitation. However, it highlights clearly the significance of this research, which makes this research unique and important to the construction industry.

Chapter 2 Literature Review:

The literature review provides an overview of the history of this topic and gives a general background about the PCS. This chapter enriches the reader information with fundamental information about the topic, in which, it covers some of the previous research; to highlight the main factors that are affecting the use of the PCS. Also, it shows the main construction systems that are commonly used.

Chapter 3 Research Methodology:

This chapter identifies the research tools that used to conclude the result which makes this work significant, unique and important to the construction industry in SA. Also, it describes all of the procedures used to answer the questions and describes the process of developing the questionnaire and validating the data.

Chapter 4 Affecting Factors:

This chapter selects the main govern factors the affecting the use of PCS among the factors highlighted in chapter 2. Then it describes and explains these factors separately in more details to illustrate how each factor affects the use of the PCS.

Chapter 5 Data Analysis and Results:

This chapter analyzes the collected date through questionnaire to highlight the most significant factors that affecting the use of the PCS in SA. Furthermore, it discusses these factors much more deeply and links them with the use of the PCS in SA. Finally, it describes the factors that are affecting the usage positively as well those affecting the usage negatively.

Chapter 6 Conclusions and Recommendations:

This chapter concludes the results of the thesis, and it points to the problem and provides the solutions, in which, it describes the main factors that must be considered by the clients, consultants and contractors in selecting the PCS as a construction system. Also, it ranks the factors. This chapter provides recommendations to enhance the use of the PCS in SA. Finally, it gives suggestion about future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview / Definition

The PCS is considered as one type of the industrialized building systems (IBS) (Badir, Kadir et al. 2002).See figure 2

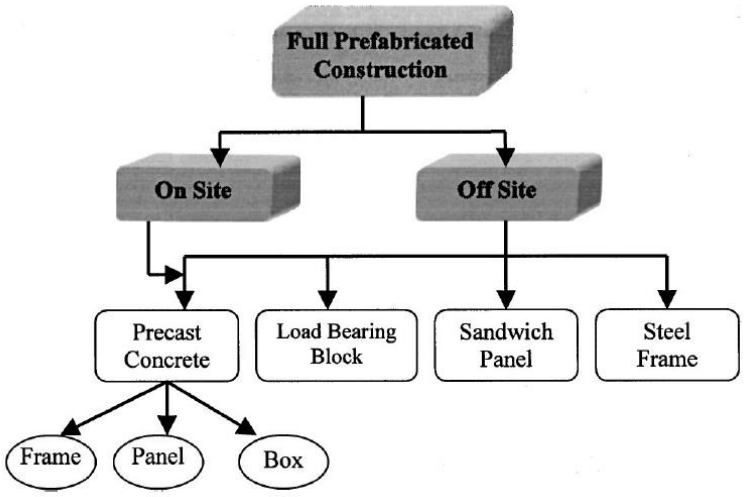


Figure 2 : Classification of Full Prefabricated Construction. (Badir and Raziali, 1998)

To date, there is no universal definition commonly used for the Industrialized Building System (IBS). Other authors may use the term offsite or prefabricated instead of IBS (Kamar, Hamid et al. 2011). (Trikha 1999) classified IBS as "a system in which concrete components prefabricated at sites or in factories, are assembled to form structures under strict quality control and minimum in situ construction activity." Also, IBS can be defined

as to build with elements or components that are prefabricated at the factory under controlled environment with standardized shapes and dimensions, then transported to the site to be assembled there (Kamar, Alshawi et al. 2009)(Badir, Kadir et al. 2002). Figures 3 to 6 show different examples of precast concrete buildings.

Figure 3 PCS 1 - LULU Hypermarket Dammam.

Figure 4 PCS 2- LULU Hypermarket Dammam.

Figure 5 LULU Hypermarket in its final shape Dammam.

Figure 6 Final shape of a precast concrete building.

The PCS is the most common used type of IBS. Since the PCS is not a tradition construction system, it needs experts to deal with all of its building process (Polat 2008). There are different factors affecting the use of the PCS.

The affecting factors are carefully selected through an extensive research. According to the previous studies, the following factors are the most significant factors that are affecting the use of the PCS:

- Demand for Large Projects/Housing Projects.

- Level of Standardization.
- Experts.
- Design Issues.
- Transportation.
- Union/Governmental Politics.
- Communication among Parties.
- Cost Savings.
- User Satisfaction.
- Buildability.
- Quality.
- Speed of erection.
- LEED (Environment Effect).

2.2 Extensive Literature Review

(Polat 2008) Conducted a survey to evaluate the factors affecting the use of the PCS in the United States. In this study, the factors were clarified and compared to the finding of the previous study done on 2000 by (Arditi, Ergin et al. 2000). In (Polat 2008) work all of the factors were evaluated to find the changes happened to the precast sector in the United States during 11 years from 1995 to 2006.The main factors are Level of Standardization, Expertise, Design Issues, Transportation, Union Politics, Communication among Parties, Cost Savings and User Satisfaction(Polat 2008)(Arditi, Ergin et al. 2000). These factors are originally given by (Arditi, Ergin et al. 2000) and reused and reevaluated by (Polat 2008). Under each factor, different questions were developed to evaluate the factor clearly.

Education effect in the use of the PCS was evaluated and clarified. Also, the study expected a future of the precast system based on the finding and how they vary from the previous study done on 2000.During the 11 years, some factors such as compatibility problems, architectural creativity and the poor or inconsistent performance of precast concrete buildings in earthquakes are changed and eliminated whereas the other still valid and have their negative impact on the precast sector.

(Arditi, Ergin et al. 2000) explored the factors that hindered the PCS from use in United Sates by mail surveys. Surveys were sent to 100 contractors, 100 design firms, 100 precast concrete manufacturers, and 100 local labor unions. In this research, it was found that the construction market at United State satisfied almost all of the provisions for the extensive use of industrialized building systems. However, there are different factors that are negatively affecting the use of the PCS in the United States such as the shortage of experts in precast. In addition, the engineering curricula in the United States did not provide enough education about precast and industrialized building systems. Many contractors were not aware of the capabilities of precast systems, and they did not know strength points of the PCS. (Arditi, Ergin et al. 2000) conducted his research on 11 main factors that were affecting the use of the PCS in the Unites States. The effect of each factor was evaluated using questionnaire survey, which mailed to contractors, design firms, precast concrete manufacturers and local labor unions. Some questions in the contractor survey were different from design firm survey as well with the survey of precast concrete manufacturers. The main 11 factors were:

- Demand for Large Projects.
- Government Funded Projects.

- The level of Standardization.
- Expertise.
- Design Issues.
- Transportation.
- Union Politics.
- Communication among Parties.
- Cost Savings.
- User Satisfaction.
- Future.

(Polat 2010) conducted a study to evaluate the factors that prevented the extensive use of PCSs in Turkey and United States. In the Polat research, a comparison between the factors that controlled the extensive use of PCSs in Turkey and United States was conducted. In Turkey, it was not clear what factors that were mainly controlling the use of precast systems. Whereas in the United States the survey participants said that size and load restrictions on transportation of precast elements, poor communication among parties, and lack of qualified contractors specialized in PCSs were limiting the extensive use of the PCS. The factors were:

- The cost of precast concrete components.
- Size and load restrictions on transportation.
- Variety of precast concrete components.
- The performance of PCSs in earthquakes.
- Availability of qualified structural engineers specialized in PCSs.
- Availability of contractors specialized in PCSs.

- Owners' capability of providing good communication among parties
- Availability of laborers specialized in PCSs
- Conformity between different PCSs.
- Labor unions' attitude.
- Occupants' level of satisfaction with precast concrete.

In the Polat study, it was mentioned that the precast manufacturers should study the preventing factors that were prevailing the extensive use of PCSs in Turkey and United States, and that to avoid these factors and to enhance the market share for PCSs.

(Glass and Pepper 2005) conducted a study in the UK to investigate the factors affecting the use of precast concrete cladding (PCC). The aim of the study was assessing the precast market at the UK and how much the awareness was about precast concrete cladding. Interviews were conducted to evaluate the affecting factors as well the awareness of precast concrete cladding. Through the interviews, the factors that positively affected the use of precast concrete cladding were highlighted as well as the factors that negatively affect the use of precast concrete cladding. The factors that were determined by Glass were:

Factors positively affecting the use of precast concrete cladding: -

- Buildability.
- Quality.
- Speed of erection.
- Off-site production/prefabrication.
- Cost competitiveness.
- Aesthetic/architectural image.
- Previous personal experience.

- Level of confidence in the product.
- Flexibility in design and shape.
- Durability.
- Panel size/dimensions.
- Alternative to natural stone.
- Environmental/sustainability.
- Design information; quality, timing, and know-how.
- Logistics and craneage.
- Previous project teams' experience.
- Weathering.
- Thermal mass.
- Client requirement/preference.

Factors negatively affecting the use of precast concrete cladding:-

- Lead time.
- Initial cost.
- Logistics and craneage.
- Aesthetic/architectural image.
- Joints and interfaces
- Weathering
- Fixings.
- Flexibility in design and shape.
- Repair and vulnerability.
- Tolerances.

- Panel size.
- Local authority requirement/preference.
- Speed of erection on site.
- Level of confidence in the product.
- Quality of finish.
- Speed of production in the factory.
- Risk – link to health and safety.

However, the first seven factors were analyzed and identified in the study. The aesthetic/architectural image was related to the personal opinion; so it was considered as positive & negative factors that affect the use of precast concrete cladding. Some of the interviewees are preferred the aesthetic of precast concrete cladding, and the other did not. Moreover, the aesthetic factor depended on the past experience of the user/client with the precast concrete cladding.

A study was conducted in Malaysia by (Trikha 1999) to evaluate the use of industrialized building systems (precast). The study investigated the problems and difficulty associated with the use of the industrialized building systems (precast) in Malaysia by the survey. As the needs of houses increased, the industrialized building systems (precast) become suitable solution to cover the high needs of houses construction with the high quality, considering that there was shortening in the workforce in Malaysia. The study investigated the following factors which affecting the use of IBS in Malaysia:

- Cost of construction.
- Cost of transportation.
- Speed of construction.

- Save in raw material.
- Total numbers of unskilled laborers.
- Total numbers of skilled labors.
- Experts.
- Initial capital investment.
- Flexibility of design.
- Heavy equipment.
- Ease of erection.
- Quality of building.

The factors that populated IBS in Malaysia were quality, the speed of construction, and cost saving. Whereas, the initial cost of investment in IBS manufacturers and the needs of experts were considered as disadvantages for IBS and they negatively affected the use of IBS.

The most significant factors among the previous factors were selected to conduct the study and investigate their effect on the use of the PCS in SA. The following 14 factors were selected; more details regarding the factors are stated in section 2 in this thesis.

1. Demand for Large Projects/Housing Projects.
2. Level of Standardization.
3. Experts.
4. Design Issues.
5. Transportation.
6. Union/Governmental Politics.
7. Communication among Parties.
8. Cost Savings.
9. User Satisfaction.
10. Buildability.
11. Quality.
12. Speed of erection.
13. LEED (Environment Effect).
14. Future.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Methodology

This chapter explains the research tools used in this study, which makes this thesis significant, unique and important for the construction industry in SA. It describes all of the procedures used to answer the questions. In addition, it gives a clear reason why this thesis is unique by describing the process that was followed to develop the questionnaire, distributing it and validating the results affecting the use of PCS in SA. These factors are discussed from the client, consultant, contractor and precast manufacturer point of view. The targeted participants' sample are classified into four main groups' clients, consultants, contractors and precast manufacturers. The main affecting factors were identified through the literature review in chapter 2, and then chapter 4 explained them in more details. All of these factors were used to prepare the preliminary questionnaire, which was finalized after the pilot study stage. Four expertise were consulted to give their feedback on the questionnaire. Once the questionnaire was corrected and reached its final stage, it was distributed to the targeted sample of participants through electronic mail and a limited number of interviews. The participants were carefully selected from the best professional/experts in their field. The research populations are as follows owners, consultants, contractors and precast concrete manufacturers. The questionnaire was sent to more than 400 email address, where around 330 of them experienced the questionnaire, but

only around 171 participants filled out the questionnaire. However, the strict conditions and the acceptance rules of this thesis that mentioned in section 3.6 eliminate some of the participants' data; finally, the total number of the accepted participants was 140 among all owners, consultants, contractor, and manufacturer who have adequate experience working in SA. All of the collected data were analyzed using SPSS software to study and test the hypotheses statements. As a result of this analysis, the master/prime factors that are affecting the use of PCS were selected and identified. Deep study and investigation of these factors are performed in chapter 5 to reach the result, conclusion, and recommendation of this thesis. The deep study is performed using the descriptive analysis technique (Montgomery 2014), which is to find the effect of each factor of the most significant factors on the use of the PCS in SA. Accordingly, the positive/negative impact of these factors on the using of the PCS in SA were defined.

The research methodology is summarized as per the following steps:

1- Review literature to find/collect the most common factors that are affecting the use of the PCS.

2- Collect the data needed to identify, investigate and study the factors affecting the use of the PCS in SA through questionnaire survey method.

3- Distribute the questionnaire to owners, consultants, contractors, and precast concrete manufacturers.

4- Analyze the data using different statistical tools to:

    a. Define/Investigate the most common factors.

    b. Select master/prime factors that have min 90% confidence level.

    c. Study the effect of these factors.

d. Define the factors the positively/negatively affect the use of the PCS in SA.

5- Provide recommendation to enhance the use of the PCS in SA.

6- Conclusions and discussions.

3.1.1 Samplings

The research covers the whole Kingdom of SA. The research populations included owners, consultants, contractors and precast concrete manufacturers who involved in the precast project in SA.

3.1.2 Data Collection

The data for this study was collected through questionnaire survey sent by E-Mail and interview with experts as mentioned early in the research methodology. The questionnaire was distributed to owners, consultants, contractors, and precast concrete manufacturers. Interviews were conducted with experts in the PCS. The targeted participants/group were defined and the participants were asked to evaluate the factors by giving them a number 1 to 5 as for how much they agree/disagree with the statement that related to the specific factor, where 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree & 5= Strongly Agree. In the questionnaire, there were around three questions to represent each factors effects to evaluate its effects on the use of the PCS.

3.1.3 Data Analysis

The main critical prime factors affecting the use of PCS were identified using statistical analysis techniques. The 5 points ranking system was used to evaluate the collected data.

The SPSS software and MS-Excel were used to analyze the data (Abo Abdo 2017). The following steps summarized the data analysis procedures:

1- Find/Collect the most common factors that are affecting the use of PCS – by literature review.
2- Select the master/prime factors that have 90% confidence level, by SPSS-regression. Where nine factors become the most significant.
3- Study the effect of these factors by descriptive analysis technique.
4- Define the linear relationship between the factors and their effects on the use of the PCS in SA.
5- Define the factors the positively/negatively affect the use of the PCS in SA.

3.2 The Design of Preliminary Questionnaire

The affecting factors that were listed in the questionnaire were selected and prepared based on the extensive literature review. Around three were developed under each factor to allow for measuring how each factor is affecting the use of PCSs in SA either positively or negatively. The questionnaire was formed of four main parts as following:

Part 1-Introduction Question: Participants were asked to define the field where they were working either owner/client, consultant, contractor or precast manufacturer.

Part 2- Personal/General Information: Participants were asked to provide general information such as years of experience, company classification and size of the business from the financial point of view.

Part 3- Questionnaire Main Body: participants were asked to evaluate the 13 factors by answering the questions under each factor, total 34 questions. The evaluation was based on a rate from one to five as described before.

Part 4- Participate in The Result: In this optional part of the questionnaire, participants were asked to list any additional factor where they believe that it was affecting the use of PCSs in SA and it was not listed above. Moreover, they were asked to give their mobile number and email ID; in case they would like to know the result of the questionnaire. Fortunately, many of the respondents holding top management positions such as CEOs and VPs provide their contacts, which means that they are interested in the topic.

3.3 Conduct a Pilot Study

The main purpose of the pilot study is to ensure that the questionnaire is well prepared, easy to be understood by the respondent and there were no deficiencies in the content, and to get the feedback from the expert for the parts that need to be improved or if couples of the question shall be added. The questionnaire of this thesis was distributed to four experts under each field client, consultant, contractor and precast manufacturers. A valuable expert' feedbacks were collected and considered to prepare the final version of the questionnaire.

3.4 Population and Sample Size Determination

The population of this study includes owners, consultants, contractors and precast manufacturers operating within the SA. There were around 25 precast concrete manufacturers in the KSA provide complete precast systems including columns, beams, slabs and cladding. However, only 10 of the 25 precast manufacturers were approved by ARAMCO, SABIC, DAR AL-HANDASAH & KING ABDULAZIZ UNIVERSITY. A similar number was considered in determine the sample size of the owners; since there is no reference number for the total numbers of owners in KSA. However, owners and consultants who operate projects with less than SR7 million were eliminated in the analysis stage. On the other hand, there were around 147+146=293 contractors classified as grade 1 and 2 as per the Ministry of Municipality and Rural Affairs (MOMRA 2017). In addition, according to Ministry of Municipality and Rural Affairs (MOMRA 2017), there were 292 consultants offices classified under Architectural/Civil consultants in SA. It must be mentioned that participants with experience less than 5 years were excluded during the analysis stage. However, people of high managerial positions such as CEO, COO, VP and senior managers, participated in filling the questionnaire. Respondents from the targeted companies provided adequate, reliable information about the factors affecting the use of the PCS in SA. The projects' type is restricted to large buildings excluding industrial and infrastructure projects. Considering the previous restrictions, the representative sample size of the study was calculated using the following formula. (Kish, 1995)

$$n_0 = \frac{pq}{SEM^2}$$

$$n = \frac{n_0}{1 + \frac{n_0}{N}}$$

Where:

(n_0) The first estimated sample size.

(p) The proportion of characteristics measured in the population. It is expressed by; decimal equals to 0.5, which reflects that the maximum sample size is 50% of the population.

(q) (1- p) which is 0.5.

(SEM) The maximum allowed standard error. In this study, it is considered ±10%.

(n) The final estimated sample size.

(N) The targeted population size.

Using Kish equation, n_0 equals to 25 responses from the inter population (owners, consultants, contractors and precast manufacturers. The final estimated sample size for them were as follow:

For Owners/Clients:

$$n = \frac{n_0}{1 + \frac{n_0}{N}} = \frac{25}{1 + \frac{25}{25}} = 12.5 \cong 13\, responses$$

For Consultants:

$$n = \frac{n_0}{1 + \frac{n_0}{N}} = \frac{25}{1 + \frac{25}{292}} = 23.02 \cong 23\ responses$$

For Contractors:

$$n = \frac{n_0}{1 + \frac{n_0}{N}} = \frac{25}{1 + \frac{25}{293}} = 23.03 \cong 23\ responses$$

For Precast Concrete Manufacturers:

$$n = \frac{n_0}{1 + \frac{n_0}{N}} = \frac{25}{1 + \frac{25}{25}} = 12.5 \cong 13\ responses$$

3.5 Data Collection and Final Questionnaire

The final questionnaire shorten link (https://goo.gl/XUwAFJ) was sent through E-mails and LinkedIn to carefully selected participants. The questionnaire link was sent to 100 owners, 126 consultants, 126 contractors, and 50 precast manufacturers. One reminder was sent to all participants, and two reminders were sent to respondents those holding top management positions such as CEOs and VPs. Almost 350 of the participants clicked on the link, but around 171 filled out the questionnaire. The following Table 1 shows the respondents rate.

Table 1 Response Rates of Surveys

Type of Recipient	Sent	Wrong address	Required sample size	Answered	Eliminated	Net number of valid answers	Rate of valid Response Mailed _%_
Owner/client	100	7	13	31	7	24	24%
Engineering/ consultant firm	126		23	62	17	45	35%
Contractor	126		23	45	5	40	32%
Precast manufacturer company	50		13	33	2	31	62%
Total	**402**	**7**	**72**	**171**	**31**	**140**	**34%**

It is worth to mention that the number of the total valid responses increases the importance of the study.

3.6 Participants Elimination Rules

Among the total number of participant, only 140 were approved to be included in the study; due to the following participants' elimination rules:

1. Owners operating projects with less than SR7 million.
2. Consultants who operate projects with less than SR7 million.
3. Contractors of grade 3 and below.
4. Participants with less than 5 years' experience.
5. Participants with irrelevant positions.
6. Misconception filling.

CHAPTER 4

FACTORS AFFECTING THE USE OF PRECAST CONCRETE SYSTEM

4.1 Introduction

The 13 factors which impact the use of PCS in SA are carefully selected through an extensive research conducted in the literature review in chapter 2. As per the previous studies, the following factors are the most significant factors that are affecting the use of the PCS. However, only 9 of them were more significant to the Saudi market based on the collected data; which were selected to be discussed and evaluated deeply in chapter 5.

4.2 The Most Significant Factors

4.2.1 Demand for Large Projects/Housing Projects (Polat 2008).

As the demand of large projects/housing projects increases, the advantages of the use of the PCS increase. The Demand for Large Projects/Housing Projects in SA is investigated and studied to find its impact on using of the PCS. Different questions are developed to cover the effect of this factor.

4.2.2 Level of Standardization (Polat 2008).

This study aims to investigate if contractors and consultants prefer to go with the standard shape and sizes of elements provided by precast manufacturers or not. Also, it aims to study the level of contractors and consultants' awareness of PCI-certified manufacturers. Different questions are developed to cover the effect of this factor.

4.2.3 Experts (Polat 2008) (Arditi, Ergin et al. 2000) (Polat 2010) (Glass and Pepper 2005) (Kamar, Alshawi et al. 2009).

Lack of experts in precast technique is investigated and identified. Lack of structural, architectural engineers having experience in precast systems is investigated and identified as will as the lack of skilled labors (Polat 2008)(Arditi, Ergin et al. 2000)(Polat 2010). Also, this study investigates/identifies the lack of contractors who are having past experience with the precast system in SA (Glass and Pepper 2005)(Kamar, Alshawi et al. 2009). Moreover, it investigates how much the engineering curriculum at universities are rich with courses related to PCS (Polat 2008)(Arditi, Ergin et al. 2000). Different questions are developed to cover the effect of this factor.

4.2.4 Design Issues (Polat 2008) (Arditi, Ergin et al. 2000)(Glass and Pepper 2005)(Alsaqar 2010).

This factor includes different aspects that could be investigated and studied such as:

- The effect on architectural design (Polat 2008)(Arditi, Ergin et al. 2000).
- The effect on structural design i.e. resistivity of earthquakes (Polat 2008)(Arditi, Ergin et al. 2000).

- Flexibility in design and shape – limitation in the design (Glass and Pepper 2005).
- Flexibility in re-design and re-shape at the site (Alsaqar 2010). Different questions are developed to cover the effect of this factor

4.2.5 Transportation (Polat 2008)(Arditi, Ergin et al. 2000)(Polat 2010)(Glass and Pepper 2005)(Badir, Kadir et al. 2002).

Transporting the precast elements to the site is one of the processes involved in the executing of a precast building. However, the constraints on the size, shape, and weight of these elements and how they are affecting the use of the precast system in SA are investigated and studied (Polat 2010). Moreover, the impact of these constraints on the design is investigated to study the impact on the use of the PCS (Polat 2008)(Arditi, Ergin et al. 2000). Also, the effect of logistics/craneage issue associated with the transportation of the precast elements is studied and investigated (Glass and Pepper 2005). In addition to that the transportation cost and its effect on the use of the PCS is studied and investigated (Badir, Kadir et al. 2002). Different questions are developed to cover the effect of this factor.

4.2.6 Union/Governmental Politics (Polat 2008)(Arditi, Ergin et al. 2000).

Consultants, contractors, and precast concrete manufacturers are asked if they have faced any rules or policies by any official union or ministry in SA that are affecting the use of PCS negatively.

4.2.7 Communication among Parties (Polat 2008)(Arditi, Ergin et al. 2000)(Glass and Pepper 2005).

The good communication among the project parties reduces the problem and enhance all of the project progress. In the precast concrete field as the parties start communicating at early stages “design stage”, it will result in better implementation of a PCS (Polat 2010). Moreover, purchasing from the same factory that was consulted at estimation/design stage enhances the implementation of the PCS (Polat 2008)(Arditi, Ergin et al. 2000).Coordination between consultants, contractors, and precast concrete manufacturers at different stages of the project is studied and investigated. Different questions are developed to cover the effect of this factor.

4.2.8 Cost Savings

Cost is one of the biggest concerns at construction field. The impact of using the PCS on the project cost is studied and investigated. This includes initial cost, the cost of elements, transportation, erection, and skilled labors cost as well (Polat 2008)(Polat 2010)(Glass and Pepper 2005)(Badir, Kadir et al. 2002)(Kamar, Alshawi et al. 2009). Different questions are developed to cover the effect of this factor.

4.2.9 User Satisfaction

The Occupants level of satisfaction with the precast concrete building is studied and investigated through the practice of consultants, contractors, and precast concrete manufacturers (Polat 2008) (Arditi, Ergin et al. 2000) (Polat 2010). Different questions are developed to cover the effect of this factor.

4.2.10 **Buildability.**

The improvement of PCS buildability compared to the tradition construction system “cast in situ” is investigated and studied (Glass and Pepper 2005). Different questions are developed to cover the effect of this factor.

4.2.11 **Quality (Glass and Pepper 2005).**

The effect of quality in the use of the PCS is investigated and studied. Different questions are developed to cover the effect of this factor.

4.2.12 **The speed of erection (Glass and Pepper 2005).**

One of the advantages of using PCS is the speed of construction (erection); see below Figure 7 that shows the speed of erection/construction of a compound in Khobar city.

Figure 7: Precast Villas

The effect of speed of erection in the use of the PCS is investigated and studied. Different questions are developed to cover the effect of this factor.

4.2.13 Environment (Glass and Pepper 2005).

The effect of the use of the PCS in the environment is investigated and studied. Different questions are developed to cover the effect of this factor.

4.3 Future (Polat 2008).

The perception of consultants, contractors, and precast manufacturers regarding the future of construction industry in SA in general and precast concrete specifically are investigated and studied. Questions are prepared to analyze how the future may affect positively/negatively the use of the PCS in SA.

CHAPTER 5

DATA ANALYSIS AND RESULTS

5.1 Introduction.

In this chapter, the data of 140 valid responses that mentioned in chapter 3 is studied, analyzed, investigated and discussed. This is to fulfill the listed objectives of this thesis, and to get ended with the result and conclusion of the most significant factors that are affecting the use of the PCS. Moreover, the positive and negative impact of the factors on the using of the precast system is investigated and discussed.

5.2 Overview.

The participants' responses are divided into four groups (clients, consultants, contractors and precast manufacturers). Then the responses of each group are analyzed separately and together as well to find the most significant factors among the 13 factors that were introduced in chapter4. These factors were selected based on the P-value with 90% confidence level. In addition, the factors with high level of agreements among the participants' groups were selected to be studied and discussed as well.

5.3 The Usage of PCS In SA

Before discussing the factors, it must be mentioned to the spread and usability of the PCS in SA. The targeted participants were asked to evaluate the statement (The PCSs are widely

used in SA) by giving it a number 1 to 5 as for how much they agree/disagree with it, where 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree & 5= Strongly Agree.The participants scored on the average 3.56, which is between neutral and agree. Accordingly, it cannot be concluded that the PCSs are widely used in SA, even though a considerable number of responses agree that it is widely used. In addition, we cannot say that it is not widely used; so it may be concluded that the precast market is a promising market and there is a big chance for enhancement and investing. The below Figure 8 shows how the responses are distributed.

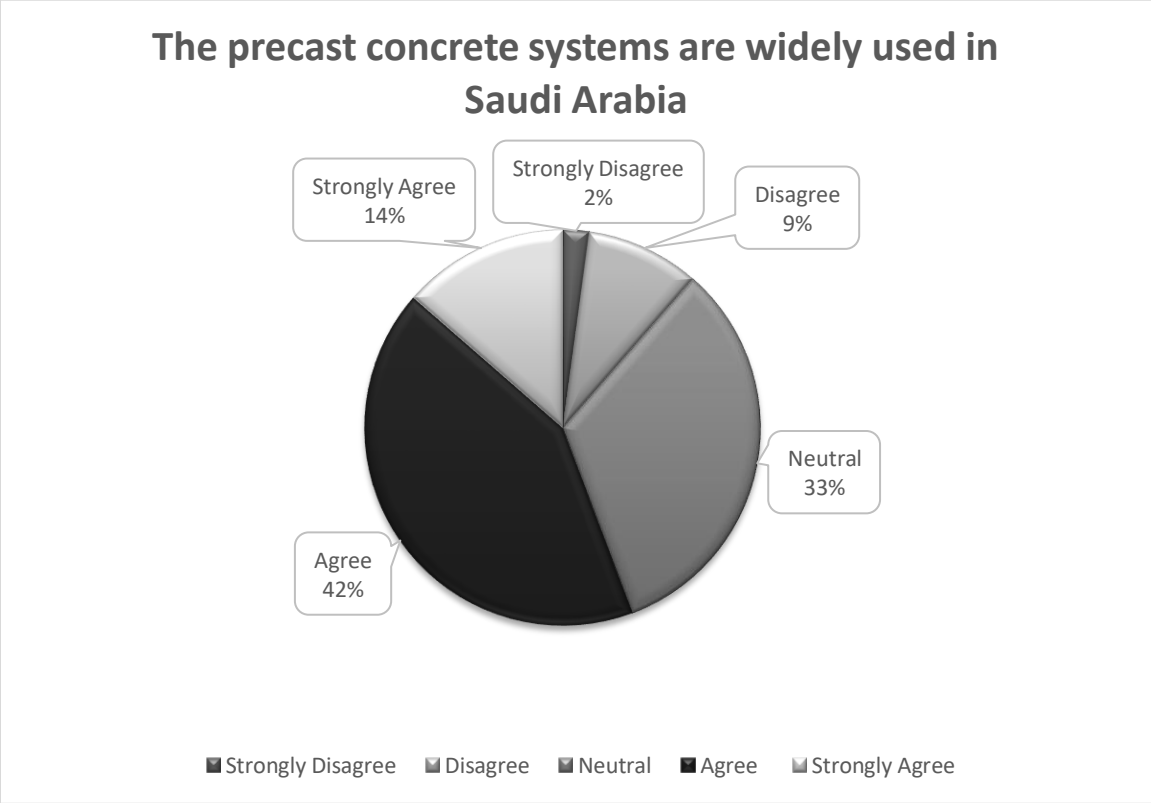


Figure 8: The popularity of the PCS usage in SA.

5.4 Discussion of Findings - Factor Affecting The Use Of PCS In SA:

Based on the literature review and the data collected,the nine most significant factors are mentioned in this chapter are:

- Demand for Large Housing projects.
- Level of Standardization.
- Expert.
- Design Issues.
- Transportation.
- Communication among Parties.
- Buildability.
- Environment.
- Cost Saving.

These nine factors are the most significant factors among the total 13 investigated factors that were mentioned in chapter 4. These factors are studied and investigated in the coming Sub-Sections.

5.4.1 **Demand for Large Housing projects**

As the demand for large projects/housing projects increases, the use of PCS increases. Massive housing projects supported by the government is creating a perfect condition and situation where PCS can be used efficiently, continuously and economically. Reference to the Eskan periodical that is produced by the Minister of Housing, the demand for massive housing projects in SA is very high. Accordingly the needs to the PCS shall be high, which investigated by a questioning the participant regarding the relation between housing projects and the use of PCS. Two questions were developed to cover the effect of this factor. The first question is (as the demand of large housing projects increases, the need for precast concrete buildings increases), while the second is (it is preferred to use the PCS in large housing projects; where the buildings are standardized). From Figures 9 and 10 it can be concluded that the relation between the demand of large housing project and the use of PCS is a very positive relation. 66% of the participants believe that as the demand for large housing projects increases, the use of precast concrete buildings increases. Where the large housing projects are creating a perfect condition and situation where PCS can be utilized. Moreover, 83% consider that the best use of PCS is in large housing projects, where the buildings are standardized.

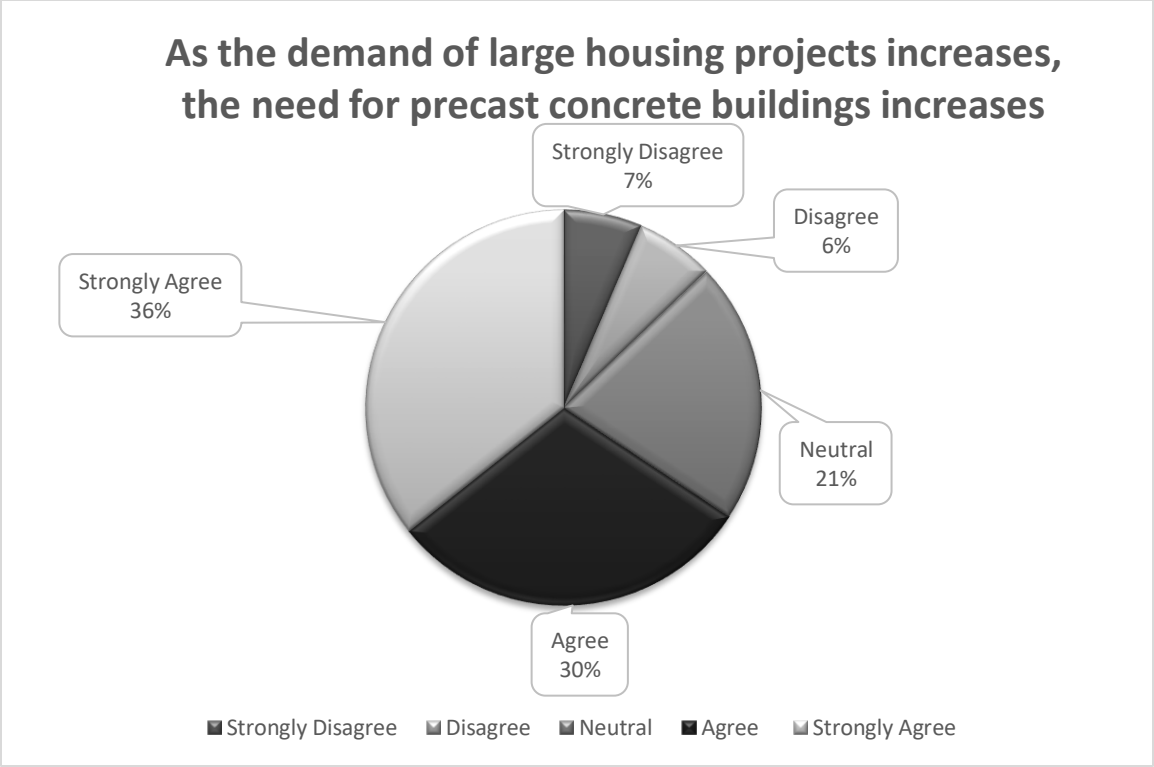


Figure 9 The demand for large housing projects and the use of PCS.

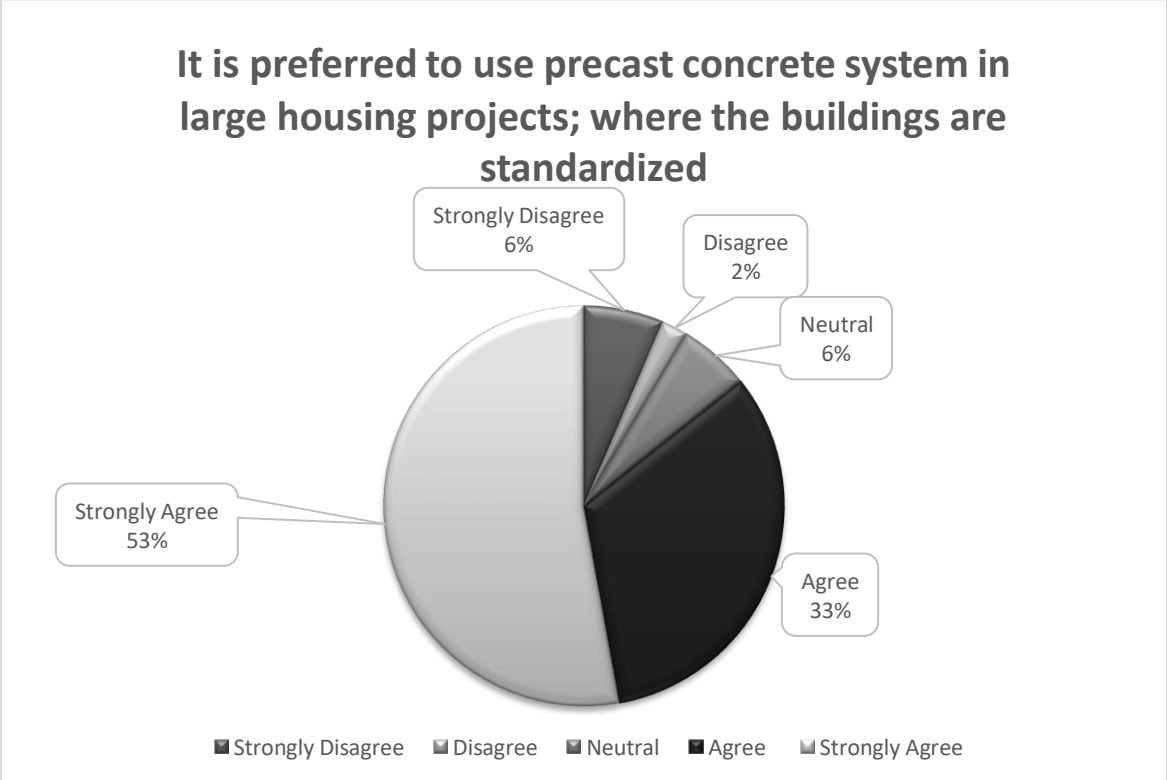


Figure 10 Is it prefer to use PCS in a housing project with standardized buildings.

5.4.2 **Level of Standardization**

Having the same shapes/sizes of precast concrete elements among the precast concrete manufacturers operating in SA is considered a major advantage of selecting PCS as a construction system. This is simplifying the consultant work during the design stage by letting consultant select the suitable precast element/member from the standard shapes/sizes available in the market. As long as the precast manufacturers produce the same standard shapes and sizes of precast elements, as the usage becomes more and more popular. Owners and contractors need to have the free choice of selecting any of the precast manufacturers to produce their building without changing or substituting any of the precast element that was initially designed. However, in some cases this standardization may limits and restricts the use of PCS, where the special or unique shape of an element is required, which forces the precast manufacturer to build a new mold to cast this specific precast element, and results in an extra cost added to the project price accordingly. In this regard, participants were asked if Precast concrete manufacturers in SA have the same standard shapes and sizes of precast concrete elements. The agreement index of this question was 2.88 which is between “Disagree” & “Neutral “and around 37% of the participants stated that Precast concrete manufacturers in SA do not have the same standard shapes and sizes of precast concrete elements, which affects the use of PCS negatively. Moreover, from Figure 11 it can be concluded that some participants, who “agree” or strongly agree’ with the statement, do not have a clear idea about the available precast products/elements in the market. This is an expected result of a weak communication/coordination between owners, consultants, and contractors from one side and precast manufacturers from the other side,

which restricts the use of PCS and shall be counted as a negative point against the use of PCS.

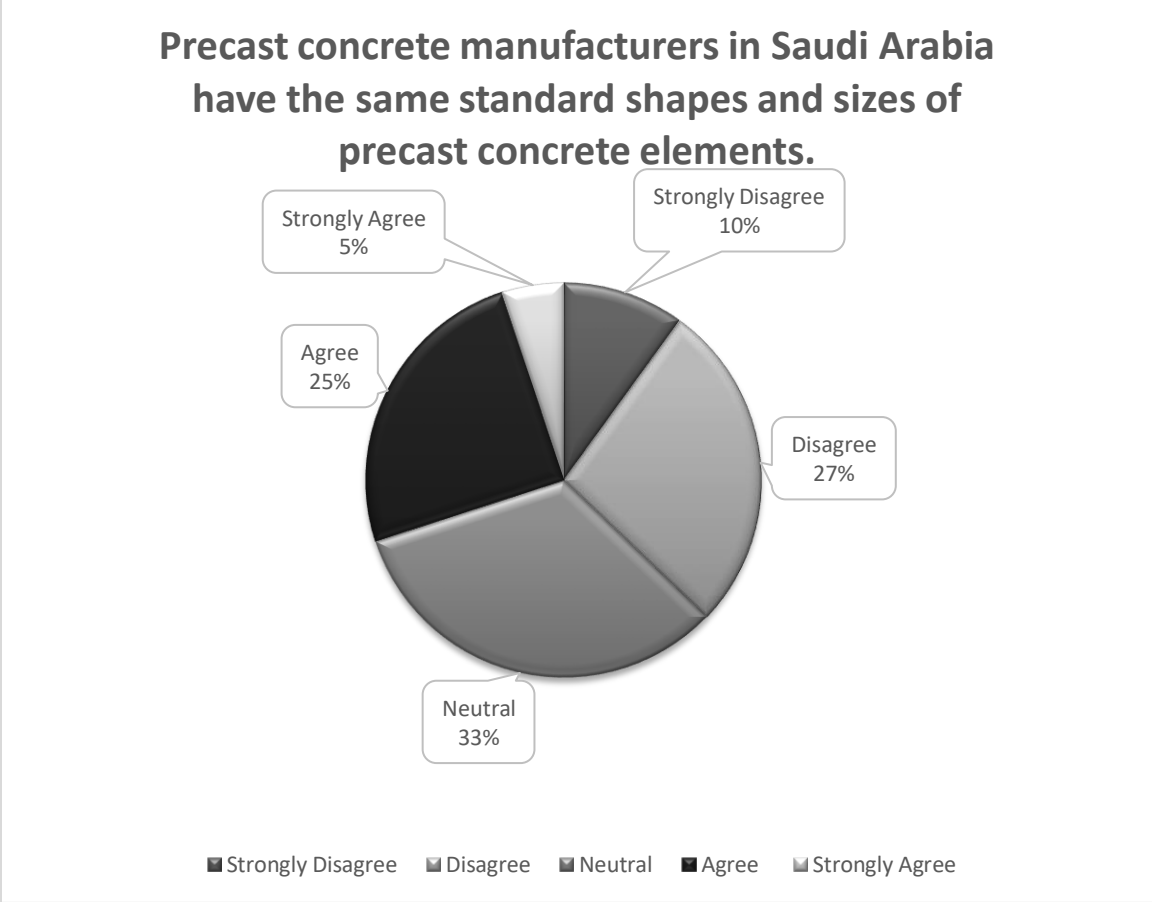


Figure 11: Level of Standardization

5.4.3 **Experts**

The relation between the availability expert and the use of PCS is a positive relation i.e. as the number of experts increases the use of PCS increases. Since lack of expertise shall lead to poor design, poor production and poor erection/management activities and at the end less people will prefer to go with such a system.

To explore the level of expertise at PCS available in both consultants and contractors' offices, the following two questions were asked:

- Consultants in SA have adequate Technical/Engineering experience in PCSs.
- Contractors in SA have adequate Technical/Engineering experience in PCSs.

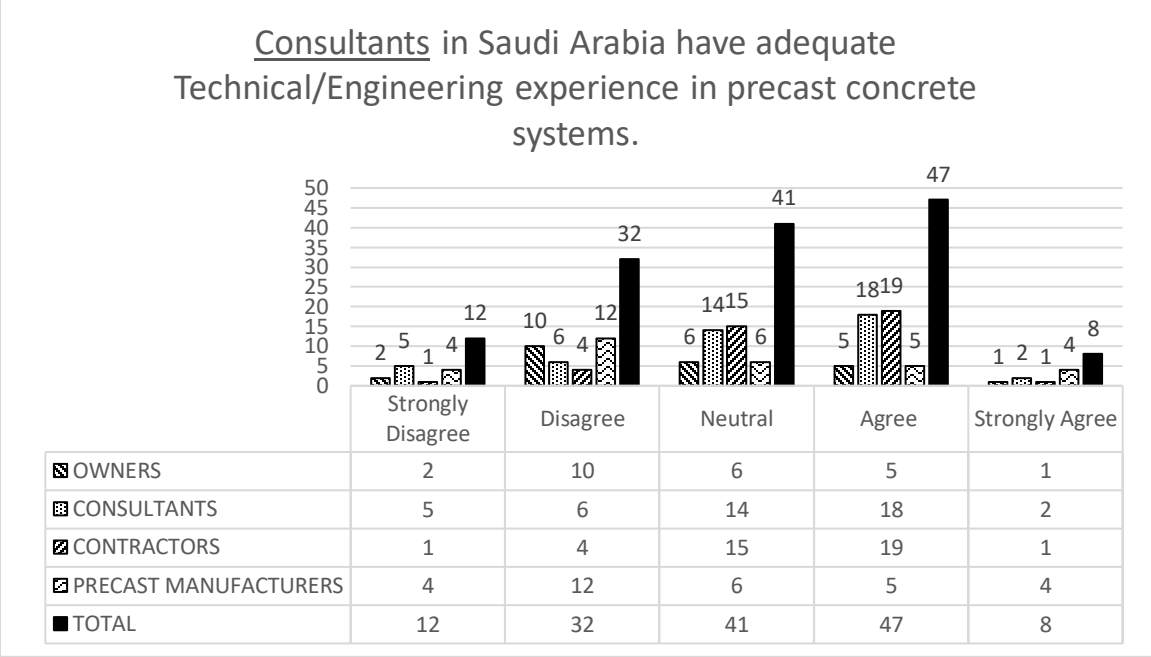
In order to have reliable answers without any prejudication; consultants' responses were eliminated in analyzing of the first question, while contractors' responses were eliminated in the second questions; since no one would have the favor of criticizing himself or say I am bad. The below Table 2 shows that there is a lack of expertise in PCS at both consultants and contractors; since around 30% of the participants with an agreement index of 3 out 5 reported that they disagree or strongly disagree. Even though around 37% of the participants agreed on both statement, but this percentage is still low and not sufficient to conclude that there is a satisfactory number of expertise those are specialized in PCS.

Table 2: How much consultants/contractors in SA have adequate experience in PCS.

Ranking/Evaluation	**CONSULTANTS** in SA have adequate Technical/Engineering experience in PCS.	**CONTRACTORS** in SA have adequate Technical/Engineering experience in PCS.
1=Strongly Disagree	7%	6%
2=Disagree	27%	22%
3=Neutral	28%	35%
4=Agree	31%	32%
5=Strongly Agree	6%	5%
Agreement index	3.01	3.08

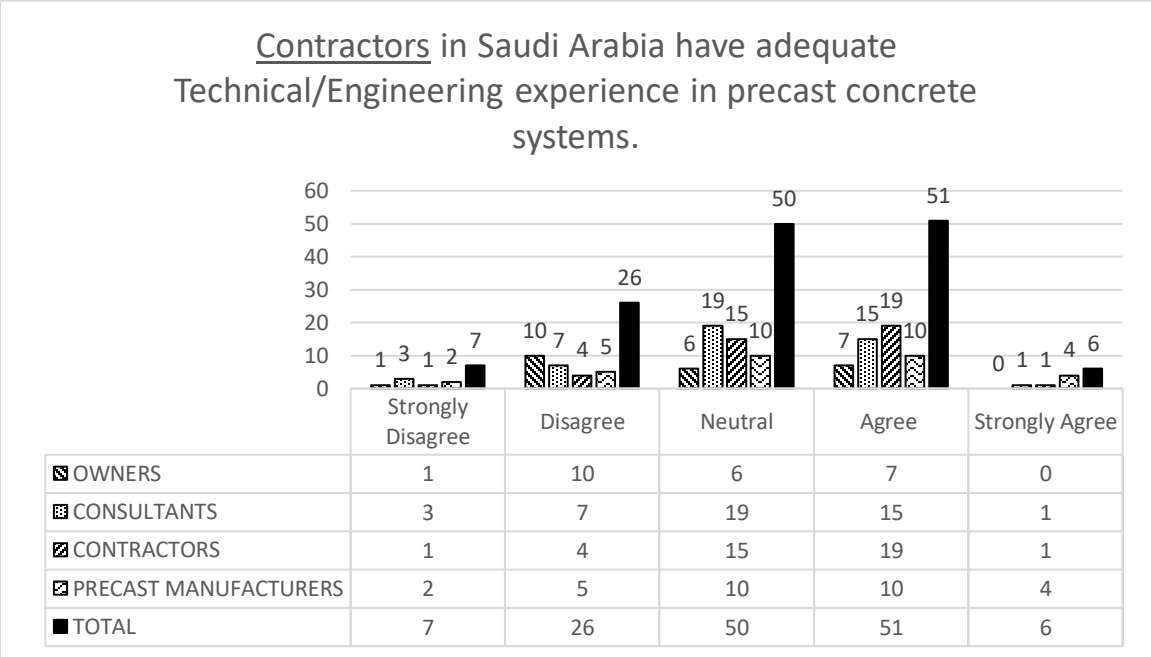
Accordingly, more care shall be taken to cover this point and to increase the numbers of expertise in either at contractors or consultants' offices. This can be achieved through conducting seminars/short courses in PCS, which should hold and sponsored by precast concrete manufacturers. However, the responses of these two questions are promising since a considerable number of participants believe that there is an adequate number of expertise in PCS.

Figures 12 & 13 below show the entire result of the above-mentioned questions regarding the technical and engineering experience in PCS of the SA market. The two figures indicate that both consultants and contractors did not reflect the actual situation of the PCS experience available in the SA construction market; as both of them tend to give the positive view of their experience, but when their responses were eliminated it shows a lack of experience as shown in Table 2.



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
OWNERS	2	10	6	5	1
CONSULTANTS	5	6	14	18	2
CONTRACTORS	1	4	15	19	1
PRECAST MANUFACTURERS	4	12	6	5	4
TOTAL	12	32	41	47	8

Figure 12 Consultant Expert in PCS.



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
OWNERS	1	10	6	7	0
CONSULTANTS	3	7	19	15	1
CONTRACTORS	1	4	15	19	1
PRECAST MANUFACTURERS	2	5	10	10	4
TOTAL	7	26	50	51	6

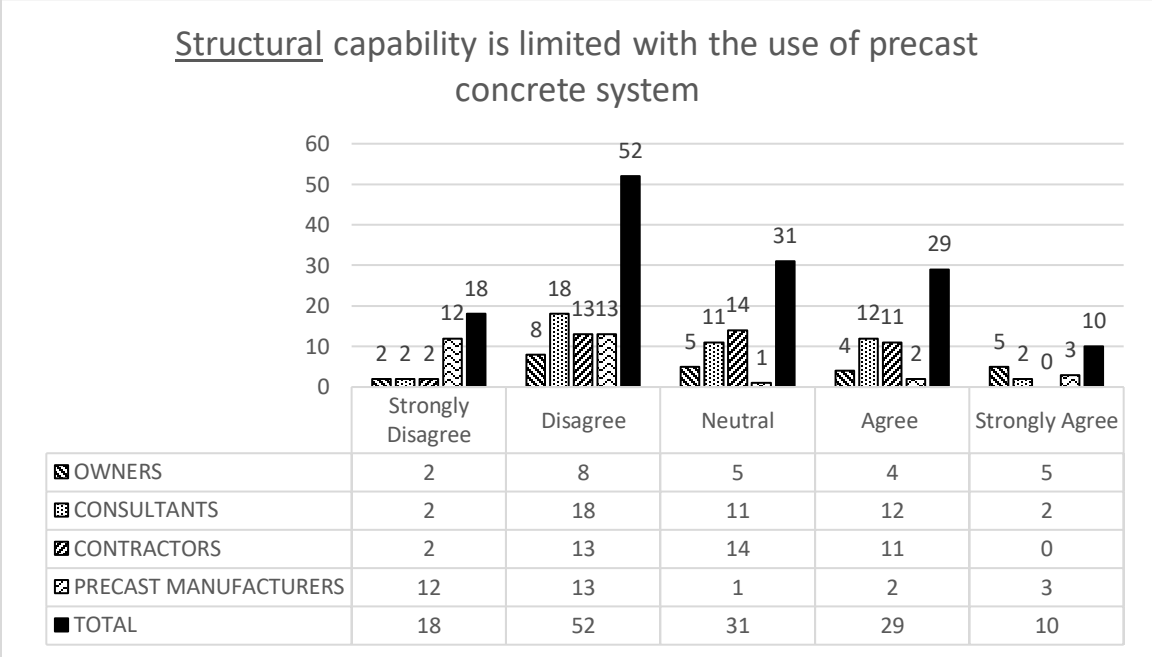
Figure 13 Contractors Expert in PCS.

5.4.4 **Design issues**

There are different concerns when it comes to the design (structural and architectural) of PCS. Even though the structural analysis of the PCS is somehow similar to the ordinary/traditional cast in situ system, but there is a considerable difference when it comes to the connection design of PCS. Moreover, all of the production/construction stages of the precast concrete elements shall be considered in the design such as demolding, transportation, erection and after erection stages, whereas these stages are not existing in the cast in situ concrete. Moreover, one of the main design concerns of using the PCS is the structural capability of the PCS in resisting the seismic forces Priestley (1993). This concern shall draw more attention while designing PCS in an area with the high seismic zone.The design of the precast connections to resist a high seismic force should be taken into consideration. Otherwise, severe collapse may occur similar to what happened to one of the precast buildings in Jizan city (saudiinews 2016). However, nowadays the structural capability of PCS is much more enhanced, and more care of elements connections is developed to withstand the high seismic forces (Polat 2010). Similarly, the building codes are significantly changed to account for the precast connection design under seismic (Ghosh 2005 & 2016)(ACI Structural Journal 2009). To secure these points regarding the structural capability of PCS and dig for their effects on the usage in SA, and to evaluate the level of market knowledge of this; the following two questions were presented to be evaluated by participants:

- Structural capability is limited with the use of PCS
- Precast concrete buildings are not suited to resist earthquake forces.

The result of these questions shows a good awareness level of structural capability of PCS; as around 50% of the participants disagree with the first statement, while 57% of the participants disagree with the second statement. Accordingly, it is concluded that the participants are aware of the structural capability of PCS, and they are updated with the last issued codes and standard. The values presented in Figures 14 & 15 conclude that most of the contractors and consultants are aware of the structural capabilities of PCS.



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
OWNERS	2	8	5	4	5
CONSULTANTS	2	18	11	12	2
CONTRACTORS	2	13	14	11	0
PRECAST MANUFACTURERS	12	13	1	2	3
TOTAL	18	52	31	29	10

Figure 14 Is Structural capability limited with the use of the PCS?

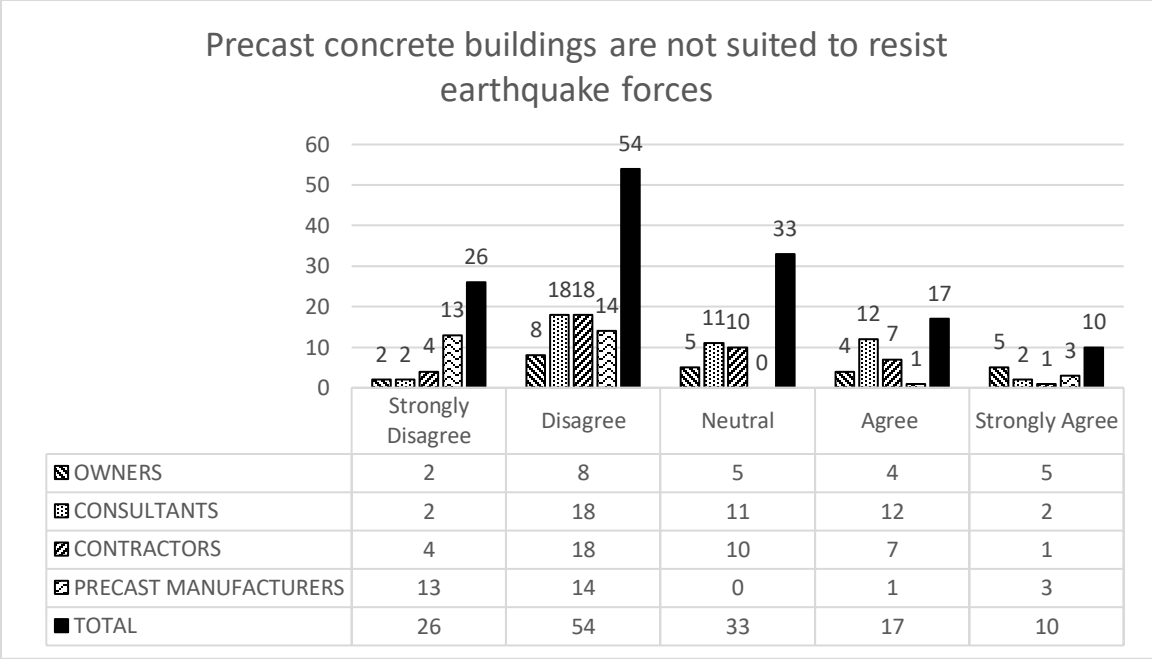


Figure 15 Are Precast concrete buildings not suited to resist earthquake forces.

On the other hand, when it comes to the architectural design of PCS we found different ideas about this subject. Some architects claim that the architectural creativity suffers when PCS is used, while the other believes that the PCS can be a great help in construct the complex patterns with high quality that cannot be produced by other traditional systems (Polat 2010). See below Figures 16 to 19 that show different complex patterns that were done using PCS with high quality, that difficult to be achieved using tradition systems.

Figure 16 complex architectural patterns - Dolci Coffe Khobar.

Figure 17 complex architectural patterns - Dolci Coffe Khobar.

Figure 18 Precast concrete cladding architectural patterns.

Figure 19 Precast Graphic Concrete - Riyadh SA.

For a better understanding of how this issue is affecting the use of PCS; participants were asked to state how much the agree/disagree with the statement that says: Architectural creativity suffers when PCSs are used. Figure 20 emphasizes the fact that there are different ideas about how PCS is affecting the architectural design either positively or negatively; since Figure 20 shows that 40% (56 of 140) believe that the Architectural creativity is not suffering when PCSs are used, while 41% (58 of 140) believe that it does.

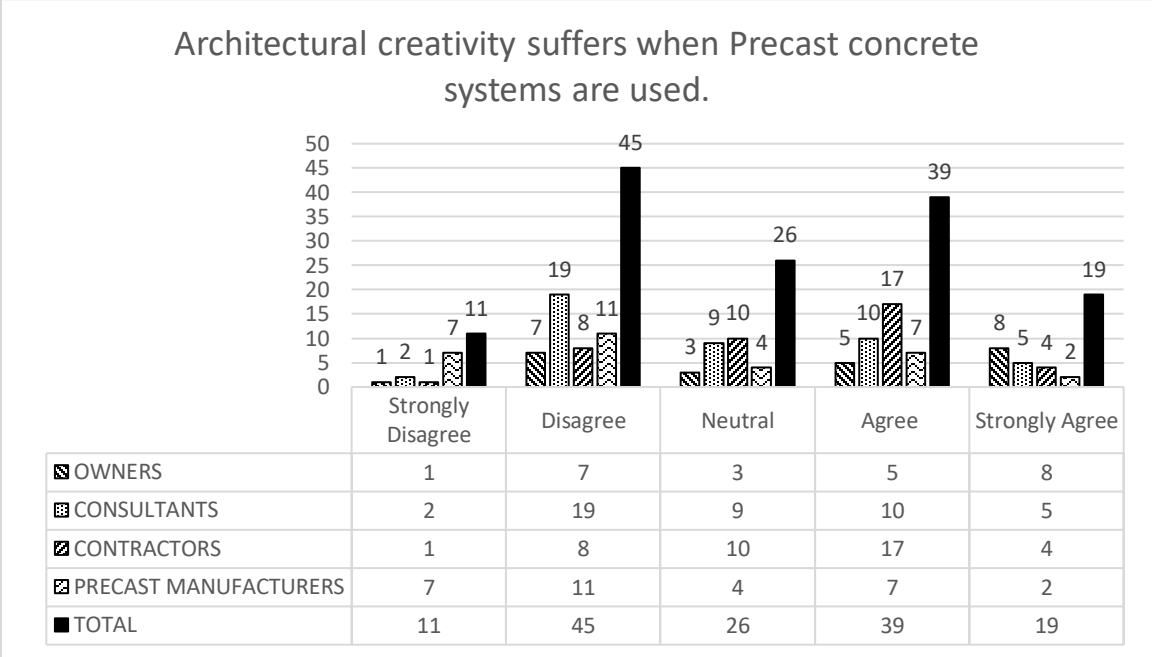


Figure 20 Does Architectural creativity suffers when PCSs are used.

In this regards, this can be concluded that in some cases the architectural ingenuity is enhanced when PCSs are used, while in the other cases it is not. This is depending on the nature of the building and design concept that needs to be achieved. Also, Figure 20 shows that 9 of the precast manufacturers agreed that the Architectural creativity suffers when PCS are used, which means that there are some real concerns about the architectural creativity of PCS. In fact, the PCS cannot be used to build a building such King Abdulaziz

Center for World Culture; as it so difficult to form such a smooth perfect curves, see Figure 21.

Figure 21 King Abdulaziz Center for World Culture.

5.4.5 Transportation

There are three main concerns under the title transportation as it is a factor affecting the use of PCS. There are different constraints in transporting of a precast element in SA such as the maximum allowed load on the truck and maximum available length of the trucks (MOT 2017). These constrain make the transportation issue an important concern that shall be considered in designing and selecting the PCS as a construction system. Keeping in mind that PCS is preferred to be used for buildings/bridges with special long spans beams, which may reach to more than 25m span, which results in a huge precast element regarding weight and length, sometimes the weight of a single precast girder reaches more than 50

ton, and the length may reach more than 30 m in length, which are exceeding the capacity/limits of the standard sizes of trucks, as per the ministry of transportation (MOT 2017). Accordingly transporting such a huge item is requiring a special truck, which costs a considerable amount of money.

Figure 22 Transporting huge precast (Delta Beam) using special truck, KSA.

Concerning the above, the design of a PCS in some cases is controlled by the transportation constraints. In this regards, participants were asked if it is easy to transport a precast element in SA or not, Figure 23 shows that around 51% of the participants believe that it easy to transport the precast element a cross the KSA, while only 24% disagree with this. This 51% is supported by the fact of the low price of fuel in SA. Also, it means that there are no governmental limitations that restrict the transportation of precast concrete elements across the KSA.

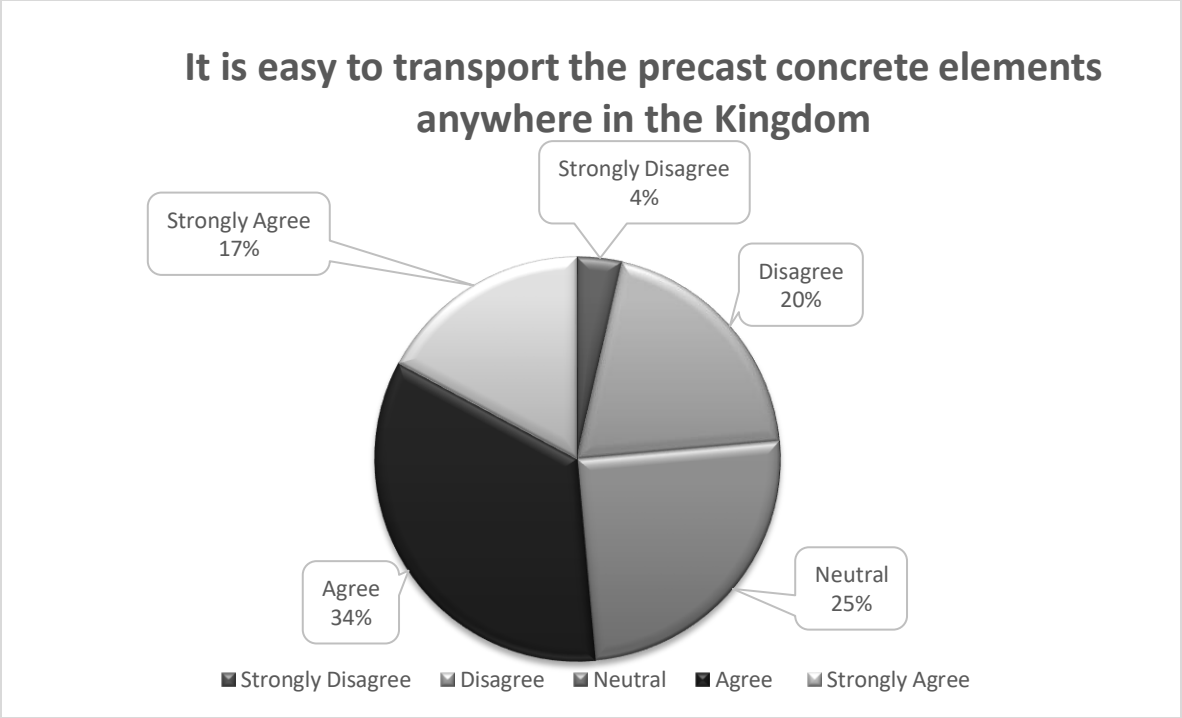


Figure 23 Is it easy to transport the precast concrete elements anywhere in KSA.

Furthermore, to know the consequence of the transportation limitations on the design activities and the cost of using PCS; the participants were asked to rank how much they agree/disagree with the following questions:

- Transportation constraints limit the design of precast concrete elements in terms of shape and size.
- The transportation cost is one of the main concerns for choosing the PCS as a construction system.

Figure 24 shows that 60% (84 out 140) of the participants 20 of the 31 precast manufacturers believe that the design of PCS is limited-restricted by the transportation constraints, which considered as a negative impact on the use of the PCS in SA.

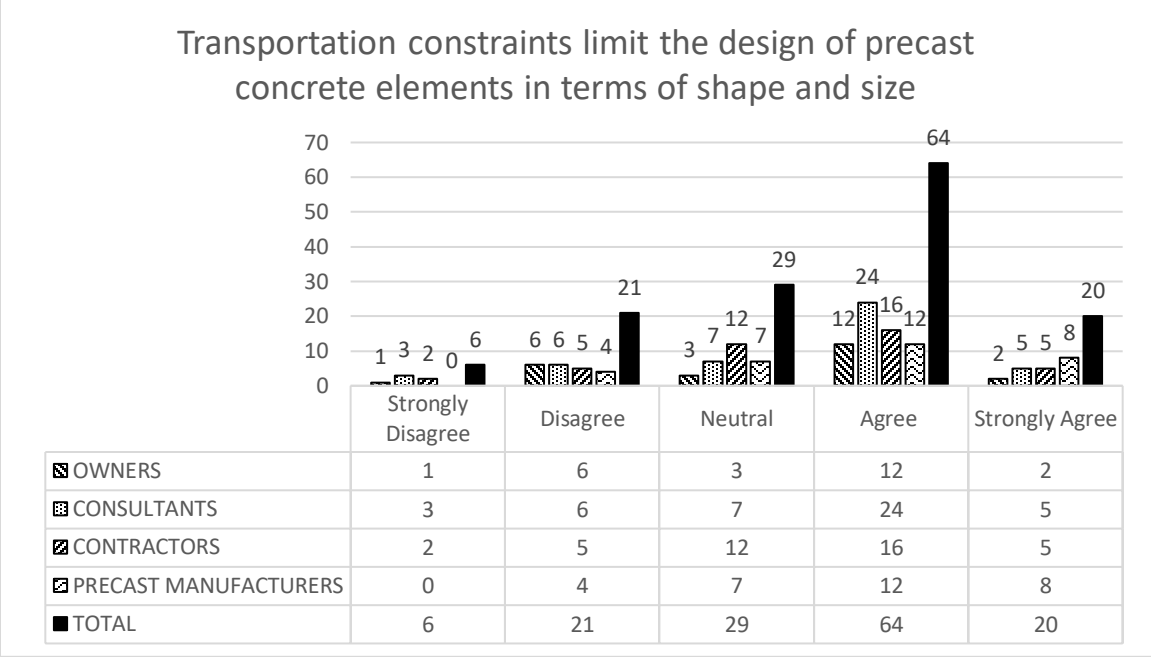


Figure 24 Effect of Transportation constrains on the design of PCS.

Moreover, Figure 25 shows that 50% of the participants believe that the transportation cost of PCS shall be considered in selecting a construction system, which means the cost of transportation is relatively high and may be considered as a barrier of selecting the PCS as a favor construction system, which affects the use of PCS in SA negatively.

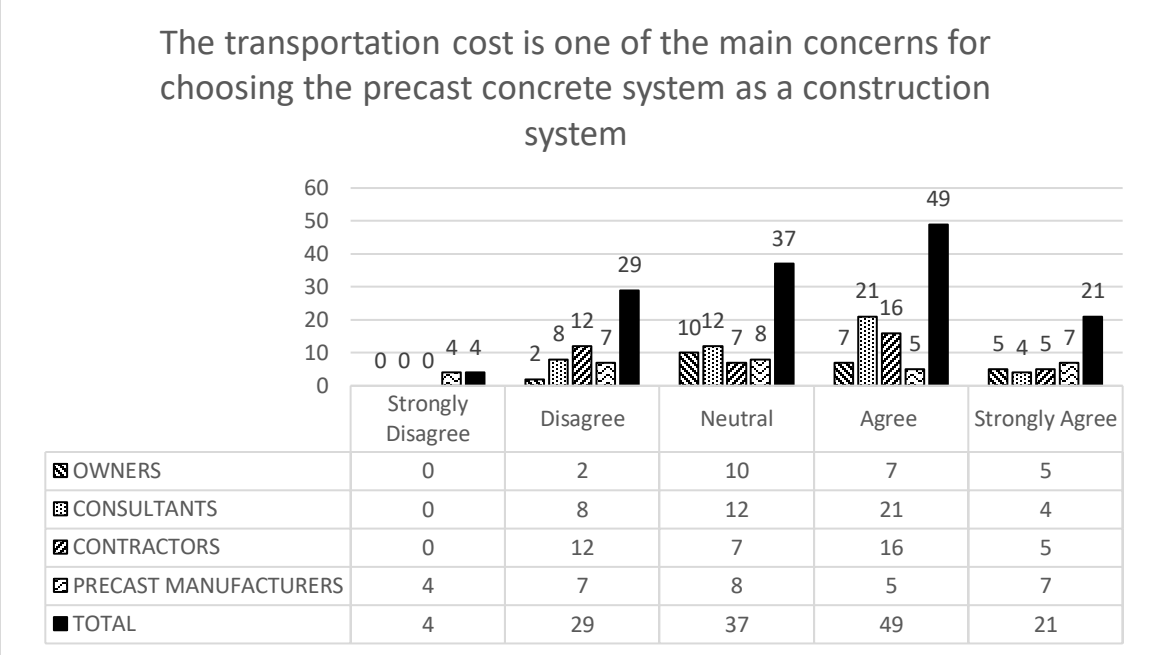


Figure 25 The transportation cost and choosing the PCS as a construction system.

5.4.6 **Communication among Parties**

One of the main advantages for the using of the PCS is the speed of construction (erection); that reduces the project cost. Despite, in some cases, a delay in erection and productions' schedule may occur, and consequently project cost will be increased (Polat 2010). This is an expected result of a poor communication and/or coordination between consultants, contractors, and precast manufacturers. The good communication and the proper coordination among the project parties will reduce the problems and enhance all of the project progress. These problems may appear at different stages of the project or after the project get completed, and resolving these problems are requiring re-work activities that are so expensive. In the precast concrete field as the parties start communicating at early stages “design stage,” as it will result in a better implementation of a PCS (Polat 2010).

For that, two questions that are addressing the communication among the parties during different project stages were presented to the participants. First, participants were asked how much they agree that (Consultants in SA involve the precast manufacturers at the early design stage of a precast concrete building).

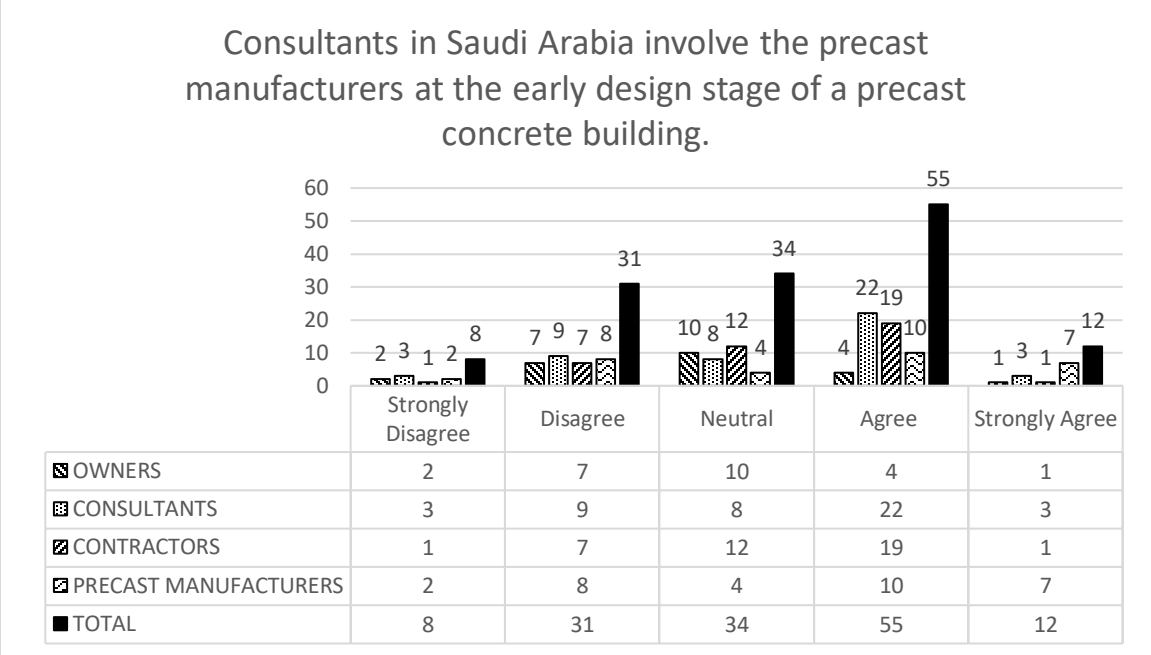


Figure 26 Consultants and the involvement of the precast manufacturers.

Figure 26 shows that around 48% (67 out 140) of the participants are agreeing/strongly agreeing that consultants involve the precast concrete manufacturers at the early design stage of a precast concrete building, which enhances the use of PCS and leads to successful implementation of the precast technique. On the other side, there are around 27% of the participants disagree/strongly disagree with the statement. This percentage is relatively high and should not be ignored; because it is considered as a barrier to the best and successful implementation of the precast technique. Consultants shall enhance their coordination and involvement of the precast concrete manufacturers at the early design stage of a precast concrete building.

Moreover, purchasing from the same factory that was consulted at estimation/design stage will enhance the implementation of the PCS (Polat 2008)(Arditi, Ergin et al. 2000); since fewer compatibility problems may appear and will require fewer coordination activities between the contractor and precast manufacturers as well. Accordingly, participants were asked if (Contractors in SA are purchasing from the same precast concrete manufacturers who were consulted at estimation/bidding stage). 30% (42 of 140) of the participants believe that contractors are not procureing from the same manufacturers who were consulted at estimation/bidding stage, see Figure 27. The participants score an average of 2.9 out of 5 between disagree and neutral, which means that contractors are tending not to procure from the same manufacturers in many cases, however, they may sometimes do. This is in line with the fact that contractors are consulting the more experienced manufacturers during at estimation/bidding stage, while they procure from the manufacturers of the lowest price; consequently, this gives more chances of compatibility problems to appear. This behavior of the contractor justifies the result shown in Figure 27 below where 43% (61 of 140) the participants have the neutral approach to this issue.

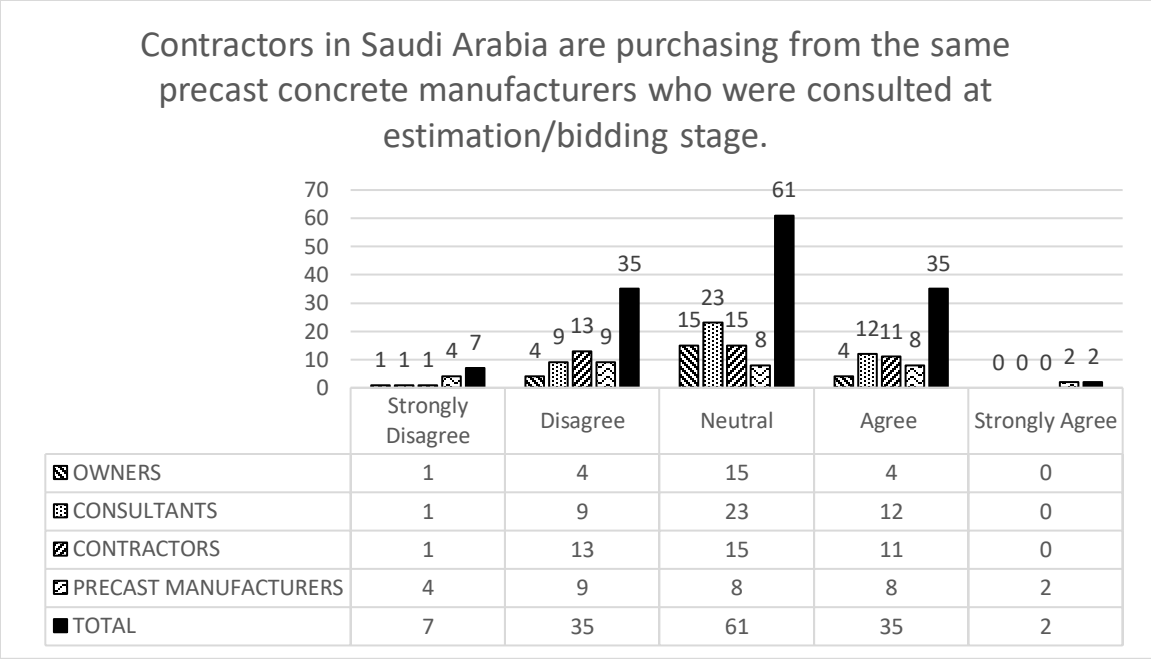


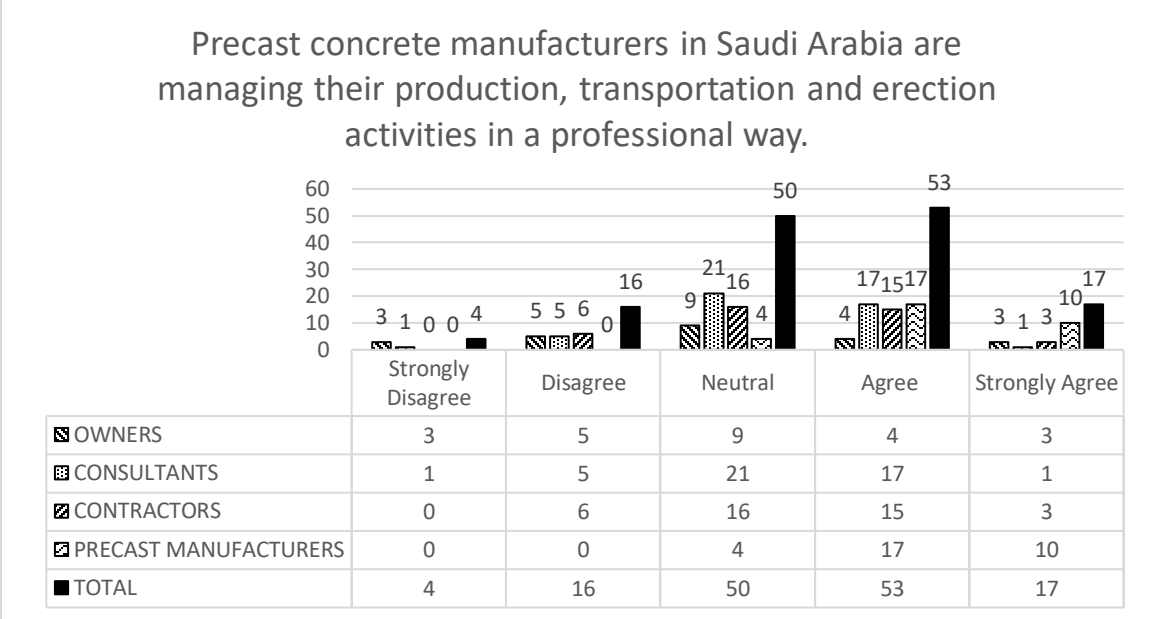
Figure 27 Contractors in SA and procurement process of PCS.

Finally, two general question were introduced regarding this subject to ensure that the subject is covered and secured properly. The two questions are:

- Precast concrete manufacturers in SA are managing their production, transportation and erection activities in a professional way.
- Precast concrete manufacturers are open to give the required Technical/Engineering support for contractors and consultants.

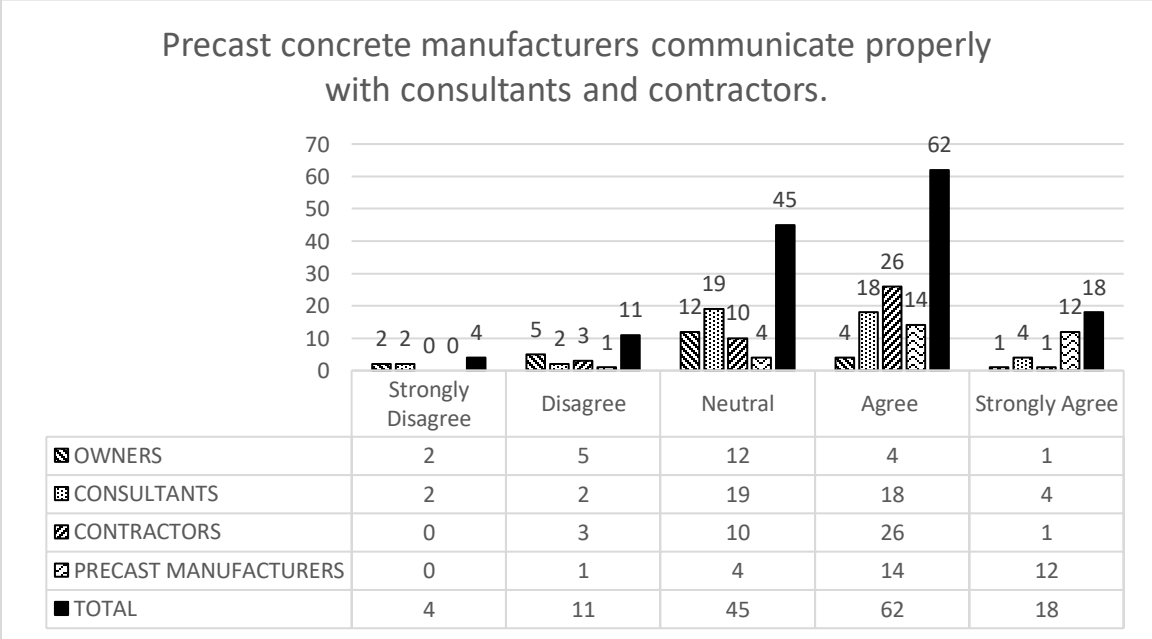
The result of these two questions in Figures 28, 29 & 30 show that precast concrete manufacturers operating in SA are capable and eligible to run the precast business.

However, there is a chance for enhancement, and this can be concluded from the number of the participants whom are selected to be neutral.



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
OWNERS	3	5	9	4	3
CONSULTANTS	1	5	21	17	1
CONTRACTORS	0	6	16	15	3
PRECAST MANUFACTURERS	0	0	4	17	10
TOTAL	4	16	50	53	17

Figure 28 Precast concrete manufacturers in SA, and their business.



	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
OWNERS	2	5	12	4	1
CONSULTANTS	2	2	19	18	4
CONTRACTORS	0	3	10	26	1
PRECAST MANUFACTURERS	0	1	4	14	12
TOTAL	4	11	45	62	18

Figure 29 Precast concrete manufacturers open to give the required Technical support.

To ensure that the result is clear, the following Figure 30 is representing the results without the responses of precast concrete manufacturers that were eliminated under these questions to have reliable answers without any prejudication and give more clear view of the subject.

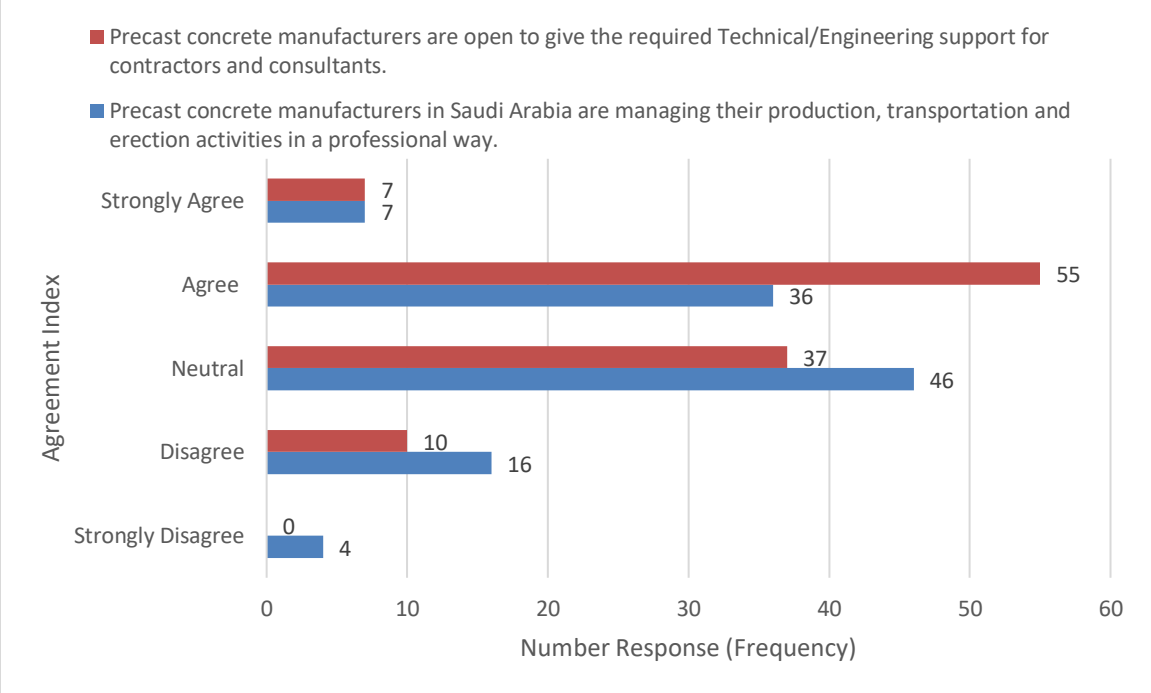


Figure 30 capability of precast concrete manufacturers to run the business in SA.

5.4.7 **Cost Savings**

Cost is one of the biggest concerns in construction field when a construction system is under investigation to be selected. (Polat 2010) Claimed that the use of PCS in a project is lowering the overall project cost. In fact, this is not always true and subjected to the nature of the building and its needs. Using PCS in a building that required beams with large spans would lower the overall project cost, and similarly, the building that required complex architectural patterns using the PCS will reduce the cost as well(Attia 2017).

Figure 31 Precast Building with large spanned beams.

On the other hand, the use of PCS for regular traditional buildings that are un-repetitive will increases the overall project cost (AbiHaidar 2017). This can be concluded out in Figure 32 below where 33% of the participants are neutral regarding the cost reduction

when PCS is used. However, 47% of the participants believe that the use of PCS reduces the overall project cost. i.e. (engineering, materials, supervision, labor cost…etc). In conclusion, the cost saving factor is positively affecting the use of PCS; so it shall be considered in chosen PCS as a construction system in compared to the traditional system, especially for the buildings that required beams with large spans.

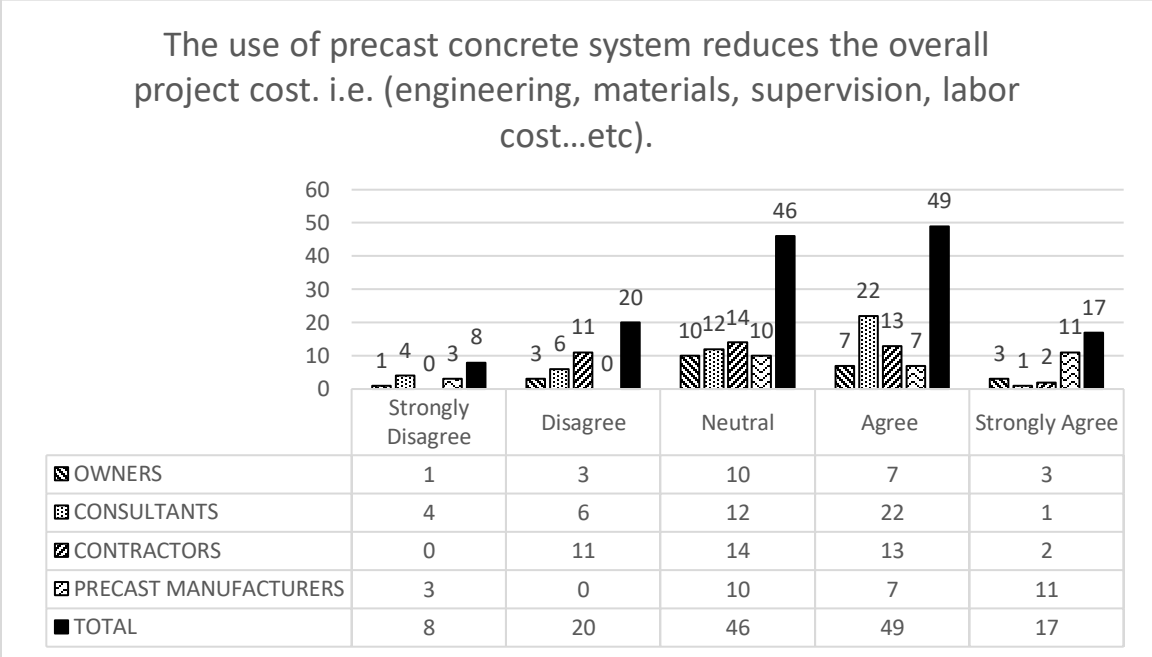


Figure 32 Cost Saving of using PCS.

5.4.8 **Buildability**

The use of the PCS is enhancing the buildability compared to the tradition construction system "cast in situ"; as less site activities are required in executing the building (Glass and Pepper 2005). Lowering the site activities result in less working hours, less coordination at sites, less supervision needed and ended with less cost accordingly. It is found that 78% (109 of 140) of the participants do believe that the execution of a precast concrete building involves fewer activities compared to the traditional system, see Figures 34 & 35 below. In conclusion, the buildability factor is positively affecting the use of PCS; so it shall be considered in chosen PCS as a construction system in compare to the traditional system.

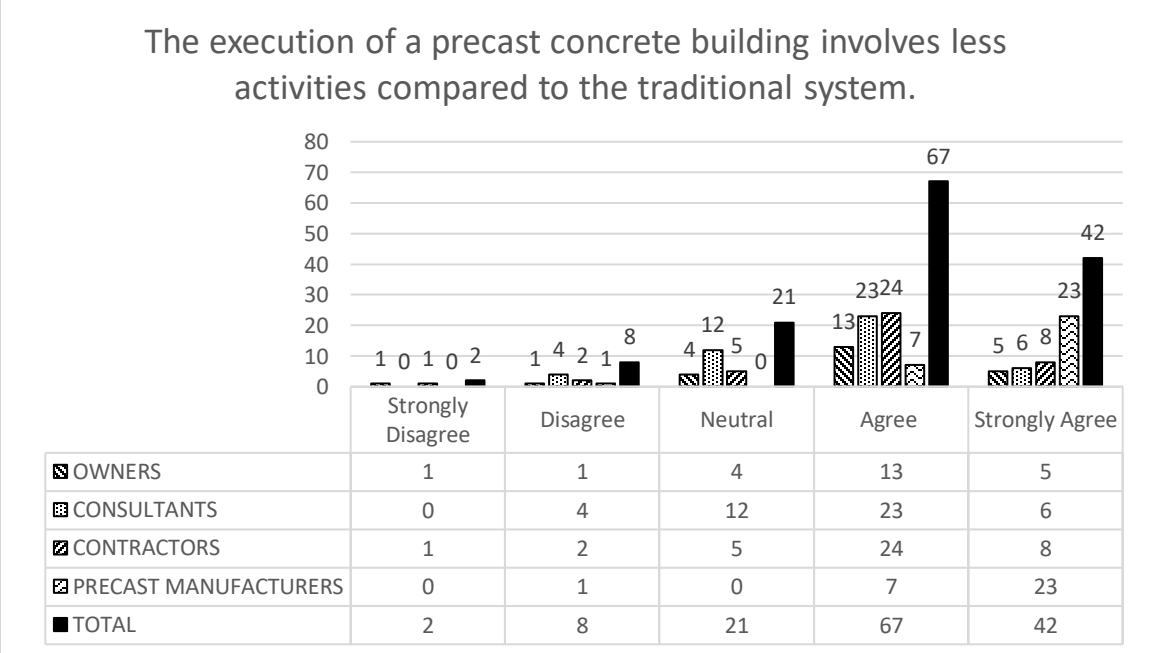


Figure 33 The buildability execution of a precast concrete building.

Figure 34 Construction activities in a busy cast in situ project.

Figure 35 Construction activities in a precast project - LULU DMM.

5.4.9 Environment

The environment becomes a big concern day by day. Nowadays in SA with KSA Vision 2030 vision that aims to manage KSA finances efficiently and effectively. The thing that plays a big role in directing the construction industry to select and use new construction systems that more economical, efficient, durable and environmentally-friendly, which will save more money and energy. So, as the construction system is more environmentally-friendly as more it will be used. The PCS is considered as environmentally-friendly. In this regards, participants were asked to provide their opinion Agree/Disagree about how much the PCS is environmentally-friendly, where the question is (PCS is environment-friendly). It is found that 72% of the participants either agree or strongly agree that the PCS is environmentally-friendly, see Table 3. While 27% were neutral, only one stated that he strongly disagree that PCS is environmentally-friendly. Accordingly, environment factor is considered as a positive factor that affects the use of PCS positively.

Table 3: Is PCS environment-friendly

Ranking/Evaluation	Frequency	Percentage %
1=Strongly Disagree	1	0.7
2=Disagree	0	0
3=Neutral	38	27
4=Agree	59	42
5=Strongly Agree	42	30
TOTAL	140	100

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Overview

In this thesis the Factors Affecting the Use of PCSs in SA has been studied, investigated and evaluated. The objectives of the study were achieved firstly by conducting a literature review to collect the factors that are affecting the use of PCS, then the most significant factors among the collected factors were selected to be studied and discussed. To study these factors their effect; the data about them were collected through questionnaire survey that sent via e-mail to more than 400 participants, while around 171 filled the questionnaire. However, among the total number of participant, only 140 were accepted to be involved in the study; due to the restricted elimination rules. The point beyond these elimination rules is to end up with a reliable and authoritative study where the one can trust it and build on. Finally, the collected data were analyzed and discussed deeply in chapter 5 to reach the result, conclusion, and recommendation of this study.

6.2 Conclusion

In the previous chapter, the most significant factors that are affecting the use of the PCS in SA are identified, investigated and discussed. The factors are discussed based on the 140 valid participants that were concluded in chapter 3. In addition, it mentioned to the positive and/or negative impact of each factor on the use of PCS as construction system in SA. The

below Table 4 summarize the main finding of this regarding the Positive/Negative impact on the use of PCS.

Table 4 Positive and Negative Impact of the factors affecting the use of PCS in SA.

The significant Factors	The sub-factor (if any)	The effect on the use of PCS in SA	Comments
Demand for Large Housing project	-	**High Positive**	
Level of Standardization	-	Low Negative	Less awareness of the PC market may be concluded.
Experts	-	Low Negative	
Design issues	Architectural	**Negative**	
	Structural	**Positive**	
Transportation	Logistic issues within the KSA	**High Positive**	
	Design is limited	**High Negative**	
	Cost of transportation	**High Negative**	
Communication Among Parties	Consultant side	**Positive**	
	Contractor side	**Negative**	
	Precast concrete manufacturers	**High Positive**	
Cost Savings	-	**Positive**	
Buildability	-	**High Positive**	
Environment	-	**High Positive**	

It can be concluded that the PCS to some extent is commonly used in SA, and it is a promising market where 66% of the participants stated that the use of the PCS will be

increasing within the next 10 years. There are different factors affecting the use of PCS in SA. Some factors have a positive impact, while the other have a negative impact on the use of PCS. To enhance the use of PCS and to get the maximum of its advantages; the positive factors shall be kept and enhanced and to eliminate the factors that negatively affect the usage as shown in Table 4.

6.3 Recommendations

The recommendations of this study are summarized as following:

1- Precast concrete manufacturers shall coordinate with each other regarding the issue of Standardization the precast level; they should reach the maximum level of standardizing the sizes of the common precast elements such as Hollow Core, I-beams, double TT slab and other elements if possible.
2- Consultants and contractors are advised to recruit architectural and structural engineers whose are experts in the PCS.
3- Precast concrete manufacturers may enhance their product specially cladding techniques to satisfy the complex architectural needs.
4- Precast concrete manufacturers shall look deeply to the issue of transportation in a matter of cost and design limitation. An alternative and creative solutions shall be found and presented.
5- Contractors is advised to procure from the same precast concrete manufacturers who were consulted at estimation/bidding stage.

6.4 Suggestions for Future Researches

The following research may be conducted in the future:

1- Re-conduct the same study considering the factors that negatively affect the use of PCS with the deep investigation, and to suggest elimination plan and alternative solutions.

2- Re-conduct the same study considering the factors that positively affect the use of PCS with deep investigation of how they can be enhanced more.

3- Generalized the study to cover the GCC area.

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Appendix A: Survey Questionnaires

2016
-
2017

QUESTIONNAIRE

Factors Affecting the Use of Precast Concrete Systems in Saudi Arabia

PRESENTED BY: AHMAD ALFARRA-0503004065
KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

A Questionnaire for a Thesis study with the title of:

Factors Affecting the Use of Precast Concrete Systems in Saudi Arabia

Company name (optional) :		Your Position:		Years of experience :	

THE FIELD YOU ARE WORKING IN IS:	
OWNER/CLIENT	
ENGINEERING/CONSULTANT FIRM	
CONTRACTOR	
PRECAST MANUFACTURER COMPANY	
Other, please specify:	

If you are the Owner/ a Client, HOW BIG IN TERMS OF FINANCES ARE THE PROJECTS YOU ARE DEALING WITH?	
Up to SR 7 Million.	
Up to SR 21 Million.	
Up to SR 70 Million.	
Up to SR 280 Million.	
Greater than SR 280 Million.	
IF YOU ARE A CONSULTANT, IN WHICH DISCIPLINE YOUR COMPANY IS CLASSIFIED/QUALIFIED?	
Civil.	
Architectural.	
Electrical.	
Mechanical.	
ALL disciplines.	
IF YOU ARE A CONTRACTOR, YOUR CLASSIFICATION IS:	
Grade 1	
Grade 2	
Grade 3	
Grade 4	
Grade 5	
PRECAST MANUFACTURER COMPANY, HOW BIG IN TERMS OF FINANCES ARE THE PROJECTS YOU ARE DEALING WITH?	
Up to SR 7 Million.	
Up to SR 21 Million.	
Up to SR 70 Million.	
Up to SR 280 Million.	
Greater than SR 280 Million.	

PLEASE FILL THE SURVEY BY CHOOSING A VALUE BETWEEN **1** AND **5** where:

1: Strongly Disagree. **2**: Disagree. **3**: Neutral. **4**: Agree. **5**: Strongly Agree.

No	Affecting Factor	Questions	1	2	3	4	5
1	Demand for Large Housing Projects	As the demand of large housing projects increases, the need for precast concrete buildings increases.					
2		It is preferred to use precast concrete system in large housing projects; where the buildings are standardized.					
3		The precast concrete systems are widely used in Saudi Arabia.					
4	Level of Standardization	The standard shapes and sizes of precast concrete elements restrict its broad use.					
5		The use of precast concrete system is more preferred for multi-story (more than 5 stories) buildings.					
6		Precast concrete manufacturers in Saudi Arabia have the same standard shapes and sizes of precast concrete elements.					
7		***Contractors*** and ***Consultants*** in Saudi Arabia prefer using the products of PCI-certified precast concrete manufacturers.					
8	Experts	***Consultants*** in Saudi Arabia have adequate ***Technical/Engineering*** experience in precast concrete systems.					
9		***Contractors*** in Saudi Arabia have adequate ***Technical/Engineering*** experience in precast concrete systems.					
10		There are many contractors/subcontractors in Saudi Arabia who are experts in the erection of precast concrete systems.					
11	Design Issues	Architectural creativity suffers when Precast concrete systems are used					
12		Structural capability is limited with the use of precast concrete system.					
13		Precast concrete buildings are not suited to resist earthquake forces.					
14		Precast system is flexible with design changes at site (after erection).					
15	Transportation	Transportation constraints limit the design of precast concrete elements in terms of shape and size.					
16		It is easy to transport the precast concrete elements anywhere in the Kingdom.					
17		In many cases, projects are delayed due to late delivery of the precast concrete elements.					
18		The transportation cost is one of the main concerns for choosing the precast concrete system as a construction system.					
19	Union regulation/rules	Labor ministry regulation/rules support the use of precast concrete system.					
20	Communication among Parties	Consultants in Saudi Arabia involve the precast concrete manufacturers at the early design stage of a precast building.					
21		Contractors in Saudi Arabia are purchasing from the same precast concrete manufacturers who were consulted at estimation/bidding stage.					
22		Precast concrete manufacturers in Saudi Arabia are managing their production, transportation and erection activities in a professional way.					
23		Precast concrete manufacturers communicate properly with consultants and contractors.					
24		Precast concrete manufacturers are open to give the required Technical/Engineering support for contractors and consultants.					
25	Cost Savings	The Cost of the precast concrete system is higher than the traditional construction system (for the same building).					
26		Erection /crane cost negatively affect the use of precast concrete system.					
27		The use of precast concrete system reduces the **overall** project cost. i.e. (engineering, materials, supervision, labor cost... etc).					

28	**User Satisfaction**	Precast concrete buildings achieve occupant's satisfaction.					
29	**Buildability/ Constructability**	Precast concrete system is easy and fast to be built /implement.					
30		The execution of a precast building involves less activities compared to the traditional system.					
31	**Quality**	Precast concrete system can reach to a quality level that cannot be reached using traditional system.					
32	**Speed of erection**	The use of precast concrete system reduces the project construction time.					
33	**Environment**	Precast concrete system is environment-friendly.					
34	**Future**	The use of precast concrete system will be increasing within the next 10 years.					

No	**Affecting Factor**	**Please specify –if any- additional Factors that may affect the Use of Precast Concrete Systems in Saudi Arabia:**	**1**	**2**	**3**	**4**	**5**

Please add additional comments or suggestions, if you have any:

Do you want to get a summary of the results of this research?		
YES		Name: E-mail: Mobile:
NO		

Thanks a lot for your cooperation
Ahmad Alfarra - King Fahd University of Petroleum & Minerals

0503004065

Appendix B: Participants Responses

OWNERS RESPONSES

#	FACTOR	QUESTIONS	RESPONSES																							
1	Demand for Large Housing Projects	As the demand of large housing projects increases, the need for precast concrete buildings increases.	3	4	1	3	4	4	5	3	3	4	2	4	5	4	4	3	5	2	3	2	2	4	4	4
2		It is preferred to use precast concrete system in large housing projects; where the buildings are standardized.	3	4	5	3	3	5	5	3	3	2	4	4	5	3	5	4	3	5	5	1	2	4	3	2
3		The precast concrete systems are widely used in Saudi Arabia.	1	4	5	3	3	4	5	4	4	2	5	5	5	5	4	5	5	5	5	4	4	4	5	1
4	Level of Standardization	The standard shapes and sizes of precast concrete elements restrict its broad use.	5	3	1	3	4	4	3	4	4	4	2	3	3	3	4	4	4	3	4	3	2	2	5	2
5		The use of precast concrete system is more preferred for multi-story (more than 5 stories) buildings.	1	2	3	3	3	3	1	2	2	3	2	4	4	4	5	4	3	1	4	4	3	2	2	4
6		Precast concrete manufacturers in Saudi Arabia have the same standard shapes and sizes of precast concrete elements.	4	4	3	3	4	4	3	3	3	3	3	3	2	3	3	3	2	3	2	3	3	4	4	3
7		Contractors and Consultants in Saudi Arabia prefer using the products of PCI-certified precast concrete manufacturers.	5	3	3	3	4	3	5	3	5	3	3	4	3	3	3	2	3	3	3	3	3	5	3	3
8	Experts	Consultants in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	1	3	3	3	4	3	4	2	3	2	2	4	3	2	2	2	4	2	5	1	2	4	2	2
9		Contractors in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	1	3	3	3	4	3	4	2	3	2	2	4	4	2	2	2	4	2	4	2	2	4	3	2
10		There are many contractors/subcontractors in Saudi Arabia who are experts in the erection of precast concrete systems.	1	3	4	2	3	3	2	2	4	2	2	3	4	3	2	2	2	2	4	1	2	3	2	2
11	Design Issues	Architectural creativity suffers when Precast concrete systems are used.	5	5	1	3	3	2	5	4	2	5	4	2	2	3	4	4	2	2	5	5	5	2	4	5
12		Structural capability is limited with the use of precast concrete system.	5	4	1	3	3	5	5	2	3	3	1	2	2	2	2	4	4	2	5	5	4	2	3	2
13		Precast concrete buildings are not suited to resist earthquake forces.	5	3	1	3	3	5	5	1	2	2	2	4	1	3	2	3	4	1	4	5	3	3	2	2
14		Precast concrete system is flexible with design changes at site (after erection).	3	2	2	2	4	3	1	1	2	1	2	2	2	4	2	1	2	2	4	1	2	3	2	1
15	Transportation	Transportation constraints limit the design of precast concrete elements in terms of shape and size.	5	4	3	3	4	3	5	2	4	4	2	4	1	4	2	4	4	2	4	4	2	4	4	2
16		It is easy to transport the precast concrete elements anywhere in the Kingdom.	1	4	3	3	3	3	4	2	3	2	4	2	5	4	4	2	4	3	1	1	1	3	3	2
17		In many cases, projects are delayed due to late delivery of the precast concrete elements.	5	5	3	4	4	3	4	4	3	5	1	4	2	4	2	4	2	2	2	5	4	2	3	5
18		The transportation cost is one of the main concerns for choosing the precast concrete system as a construction system.	3	5	3	3	3	3	3	4	4	5	2	5	3	3	4	4	2	3	5	5	4	4	4	3
19	Union regulation/rules	Labor ministry regulation/rules support the use of precast concrete system.	3	4	2	3	3	3	3	2	3	3	3	3	2	3	3	4	3	3	5	3	3	2	2	3
20	Communication among Parties	Consultants in Saudi Arabia involve the precast manufacturers at the early design stage of a precast concrete building.	3	3	3	3	3	3	3	4	4	1	4	2	3	4	2	2	2	3	5	1	3	2	2	2
21		Contractors in Saudi Arabia are purchasing from the same precast concrete manufacturers who were consulted at estimation/bidding stage.	3	3	4	3	3	3	3	4	3	2	3	3	2	3	2	3	2	3	4	1	3	4	3	3
22		Precast concrete manufacturers in Saudi Arabia are managing their production, transportation and erection activities in a professional way.	1	3	3	3	3	3	5	2	3	2	2	2	4	4	3	3	5	3	4	1	1	5	4	2
23		Precast concrete manufacturers communicate properly with consultants and contractors.	5	3	3	3	2	3	3	3	3	2	2	2	2	3	3	1	4	3	3	1	3	4	4	4
24		Precast concrete manufacturers are open to give the required Technical/Engineering support for contractors and consultants.	3	3	3	3	3	3	4	4	4	3	2	2	4	3	4	2	4	3	5	2	3	4	4	2
25	Cost Savings	The Cost of the precast concrete system is higher than the traditional construction system (for the same building).	3	2	3	3	3	3	3	2	4	5	1	2	3	4	2	2	2	3	4	3	4	4	5	3
26		Erection /crane cost negatively affect the use of precast concrete system.	4	2	3	3	3	4	4	4	4	5	2	4	2	3	4	4	2	2	5	5	5	4	4	4
27		The use of precast concrete system reduces the overall project cost. i.e. (engineering, materials, supervision, labor cost…etc).	3	3	3	3	4	3	3	2	2	1	4	3	3	3	5	4	4	3	5	5	4	4	4	2
28	User Satisfaction	Precast concrete buildings achieve occupant's satisfaction.	1	4	5	3	3	3	3	4	4	2	4	3	4	4	5	3	2	3	4	1	2	4	4	2
29	Buildability/ Constructability	Precast concrete system is easy and fast to be built /implement.	3	4	4	3	4	4	5	4	5	2	5	4	5	5	5	4	5	3	4	1	4	4	4	3
30		The execution of a precast concrete building involves less activities compared to the traditional system.	3	5	4	3	4	4	5	4	4	3	4	4	4	1	4	4	5	4	5	2	4	4	5	3
31	Quality	Precast concrete system can reach to a quality level that cannot be reached using traditional system.	1	4	4	3	2	3	1	4	4	1	4	2	5	2	5	4	4	4	4	1	2	2	5	2
32	Speed of erection	The use of precast concrete system reduces the project construction time.	3	4	3	3	4	3	3	4	5	4	5	4	4	5	5	4	4	4	3	3	4	4	5	3
33	Environment	Precast concrete system is environment-friendly.	3	3	3	3	4	4	4	4	4	3	3	4	4	3	5	3	5	3	4	1	3	4	5	4
34	Future	The use of precast concrete system will be increasing within the next 10 years.	3	3	3	3	4	3	3	4	4	3	4	4	5	3	5	4	4	3	4	4	4	4	3	4

CONSULTANTS RESPONSES

	FACTOR	QUESTIONS	RESPONSES
1	Demand for Large Housing Projects	As the demand of large housing projects increases, the need for precast concrete buildings increases.	5 4 4 3 2 5 4 5 4 4 5 4 4 5 5 4 4 3 3 5 4 3 5 3 3 3 4 5 4 4 5 5 3 5 4 3 3 5 5 5 1 1 1 5 5 4 2 5 5 5 3 4
2		It is preferred to use precast concrete system in large housing projects; where the buildings are standardized.	5 4 4 4 1 5 3 5 4 4 5 4 5 5 5 3 3 5 4 5 4 3 5 3 4 4 5 4 5 5 5 5 4 5 5 4 4 5 4 5 1 4 1 5 4 4 4 5 5 5 3 4
3		The precast concrete systems are widely used in Saudi Arabia.	5 4 4 3 3 3 4 2 2 4 3 3 5 2 3 3 4 4 4 4 3 3 4 4 4 3 3 3 3 3 3 4 4 3 2 2 3 4 2 2 3 3 3 3 3 3 4 4 4 3 4 3 4 3 4 4
4	Level of Standardization	The standard shapes and sizes of precast concrete elements restrict its broad use.	3 2 4 5 2 2 4 4 1 1 4 4 3 3 4 1 2 2 4 3 3 3 3 4 4 4 2 3 3 2 2 3 2 3 4 5 4 3 2 3 4 2 2 2 4 4 3 2 4 4 1 4 2 2 4 1 2 4 4
5		The use of precast concrete system is more preferred for multi-story (more than 6 stories) buildings.	3 2 2 3 5 4 4 4 3 3 4 2 2 3 5 4 2 2 3 4 4 3 5 4 4 2 3 1 2 2 2 1 2 4 5 2 5 4 4 2 2 1 2 2 1 3 2 2 2 2 3 2 2 4 3 3 4
6		Precast concrete manufacturers in Saudi Arabia have the same standard shapes and sizes of precast concrete elements.	3 3 3 4 4 3 2 3 3 3 3 3 4 4 4 4 3 1 1 1 4 2 2 2 2 1 2 3 3 2 4 2 4 3 5 3 2 4 3 3 2 2 2 2 1 5 4 1 2 2 4 3 3 1 4 3 4
7		Contractors and Consultants in Saudi Arabia prefer using the products of PCI-certified precast concrete manufacturers.	5 4 3 4 4 3 4 3 5 3 3 4 4 5 4 4 3 3 5 4 5 4 1 3 3 3 3 4 4 3 4 5 3 3 4 4 4 5 2 4 3 2 3 3 2 4 4 3 5 5 5 4 4 4
8	Experts	Consultants in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	2 4 3 4 4 4 4 4 3 5 4 4 4 4 4 3 4 4 5 4 5 4 4 3 3 4 3 3 4 2 2 4 2 3 2 2 4 1 4 4 3 3 1 1 2 3 4 2 4 4 2 3 4 4
9		Contractors in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	2 3 3 3 4 2 4 3 4 3 3 3 4 4 3 3 4 5 3 4 3 4 1 3 4 4 3 4 2 2 4 2 3 3 2 4 1 4 4 3 3 1 4 2 3 4 3 2 4 2 3 4 4
10		There are many contractors/subcontractors in Saudi Arabia who are experts in the erection of precast concrete systems.	2 2 3 2 2 3 4 3 4 3 3 3 3 3 3 4 4 5 4 4 4 3 2 3 2 3 2 4 3 2 4 3 3 4 2 2 4 4 3 4 3 1 1 1 5 4 4 3 5 2 3 4 4
11	Design Issues	Architectural creativity suffers when Precast concrete systems are used.	4 3 4 2 2 1 1 3 3 2 3 4 2 4 2 3 5 5 2 3 1 2 2 1 1 3 3 2 3 4 4 4 4 1 2 4 4 4 5 2 4 5 2 2 2 2 2 2 4 4 4 2 1 3 4 4
12		Structural capability is limited with the use of precast concrete system.	4 2 4 2 4 3 3 4 2 3 5 3 1 2 3 3 3 4 2 2 4 2 1 3 2 3 2 2 4 4 4 2 2 5 3 4 5 2 4 1 2 2 2 4 2 4 2 4 1 1 3 4 4
13		Precast concrete buildings are not suited to resist earthquake forces.	4 3 1 4 1 1 4 3 2 2 3 2 2 1 1 3 3 2 3 4 2 1 1 2 5 1 1 3 2 2 3 2 1 2 3 3 4 2 2 2 2 2 3 3 3 4 1 1 5 2 3 2 5 1 1 3 4 4
14		Precast concrete system is flexible with design changes at site (after erection).	4 1 1 1 4 2 3 2 3 2 1 2 2 1 1 3 2 1 2 5 2 1 1 2 1 5 3 1 1 1 3 1 1 4 4 2 1 1 5 2 2 5 1 1 2 2 5 4 1 1 2 1 2 2 1 1 5 3 4 4
15	Transportation	Transportation constraints limit the design of precast concrete elements in terms of shape and size.	4 5 4 4 4 2 2 3 4 5 4 3 3 2 4 4 4 4 3 2 3 2 1 1 3 4 5 4 1 1 4 5 4 5 4 2 4 4 5 2 4 4 4 2 1 4 3 4 4 4 5 2 3 3 4 4
16		It is easy to transport the precast concrete elements anywhere in the Kingdom.	5 3 2 2 4 4 5 4 3 4 3 3 4 5 3 3 3 3 3 4 5 4 3 5 3 2 4 2 3 3 4 4 2 3 5 5 4 3 2 2 4 4 4 5 2 3 4 3 3 5 3 4 4 4
17		In many cases, projects are delayed due to late delivery of the precast concrete elements.	5 4 3 4 4 5 3 3 3 4 4 2 4 3 3 3 4 4 2 3 2 3 2 1 1 3 3 3 3 4 3 5 4 4 4 4 5 2 4 2 4 4 2 2 3 2 4 3 3 4 2 3 4 2
18		The transportation cost is one of the main concerns for choosing the precast concrete system as a construction system.	4 2 3 4 2 3 5 3 5 5 2 4 1 3 4 4 4 2 3 2 2 2 1 1 3 3 3 3 3 5 4 4 4 4 2 4 4 4 2 3 4 4 2 2 4 4 4 2 2 2 2 3 2 2
19	Union regulation/rules	Labor ministry regulation/rules support the use of precast concrete system.	3 3 3 3 2 3 3 3 3 3 4 3 3 3 4 3 2 3 3 3 4 3 1 1 5 3 3 3 2 4 3 3 4 3 3 4 3 4 3 4 2 2 3 4 4 2 3 4 4 4 3 3 5 3 3 4
20	Communication among Parties	Consultants in Saudi Arabia involve the precast manufacturers at the early design stage of a precast concrete building.	2 3 4 4 4 3 3 3 5 4 3 3 4 3 4 2 1 1 1 5 4 5 2 4 1 3 3 4 2 5 2 2 4 1 4 4 2 4 4 4 3 4 2 4 2 4 4 4 4 2 4 5 3 3 4
21		Contractors in Saudi Arabia are purchasing from the same precast concrete manufacturers who were consulted at estimation/bidding stage.	2 4 3 3 2 3 3 3 4 4 3 3 4 3 4 3 1 2 3 4 3 2 2 1 3 3 3 4 4 2 2 4 4 3 2 3 4 2 3 3 3 2 4 2 3 4 3 4 5 5 3 4
22		Precast concrete manufacturers in Saudi Arabia are managing their production, transportation and erection activities in a professional way.	2 4 3 3 4 4 3 3 4 3 4 3 3 4 2 1 2 5 4 4 4 2 1 3 3 3 3 4 3 3 4 3 4 4 4 2 4 3 4 3 3 2 4 3 4 4 4 5 4 4 4
23		Precast concrete manufacturers communicate properly with consultants and contractors.	2 3 3 4 2 4 4 3 4 3 4 4 3 4 3 1 1 5 4 5 4 4 1 3 3 3 5 3 3 4 3 4 3 3 2 3 4 4 3 5 3 4 3 4 3 4 4 4 5 4 4 4
24		Precast concrete manufacturers are open to give the required Technical/Engineering support for contractors and consultants.	4 4 3 4 2 4 4 4 3 3 4 3 4 3 3 3 5 4 5 4 2 1 3 3 4 5 4 3 4 4 4 4 2 2 4 4 4 3 5 3 2 3 4 4 4 4 3 5 3 3 4
25	Cost Savings	The Cost of the precast concrete system is higher than the traditional construction system (for the same building).	4 2 4 5 5 4 4 3 4 3 4 4 5 2 4 2 3 5 4 4 4 2 1 3 3 2 2 2 3 4 2 5 2 4 4 4 2 3 3 2 5 4 2 2 4 2 4 4 4 3 4
26		Erection /crane cost negatively affect the use of precast concrete system.	2 2 4 4 4 3 3 3 3 3 3 4 2 3 4 4 4 5 4 2 4 2 1 3 2 3 3 2 3 5 4 4 4 4 4 3 4 4 2 2 3 4 4 4 5 4 2 2 2 2 3 3 2
27		The use of precast concrete system reduces the overall project cost. i.e. (engineering, materials, supervision, labor cost...etc).	4 4 2 2 1 3 4 3 4 3 4 4 4 3 4 1 1 1 2 2 2 2 5 3 3 4 4 4 4 5 4 4 2 5 3 4 4 4 3 4 4 2 3 4 4 3 4 2 4 3 3 4
28	User Satisfaction	Precast concrete buildings achieve occupant's satisfaction.	4 4 3 1 4 3 4 3 4 3 4 4 4 4 3 3 3 4 3 4 3 3 5 3 3 3 5 4 4 4 4 3 4 4 4 2 4 4 4 3 4 4 4 1 4 4 3 5 4 3 4 4
29	Buildability/ Constructability	Precast concrete system is easy and fast to be built /implement.	5 5 4 4 4 4 4 3 4 4 4 4 4 4 4 3 3 5 2 5 4 3 5 3 3 4 4 4 5 5 4 3 5 5 4 4 4 4 4 4 5 2 4 4 4 4 4 4 5 5 5 3 4
30		The execution of a precast concrete building involves less activities compared to the traditional system.	2 5 4 3 4 4 4 3 4 4 4 3 4 4 3 3 3 5 2 4 4 3 5 3 4 3 4 4 4 2 4 3 4 4 5 4 4 4 4 4 5 3 2 4 4 5 4 4 4 5 5 3 4
31	Quality	Precast concrete system can reach to a quality level that cannot be reached using traditional system.	1 5 4 2 4 3 3 2 5 4 4 4 4 4 4 4 4 3 3 5 4 4 4 3 5 3 3 4 4 2 2 2 3 5 4 4 4 5 4 2 5 5 3 2 5 5 4 4 5 4 5 5 4 4
32	Speed of erection	The use of precast concrete system reduces the project construction time.	4 5 4 4 4 4 5 5 5 5 5 4 4 5 4 4 2 2 5 4 4 4 4 5 3 4 4 4 3 5 5 3 5 4 4 5 5 4 4 3 5 2 3 5 4 5 4 4 4 5 5 3 4
33	Environment	Precast concrete system is environment-friendly.	3 4 4 4 4 4 4 4 5 4 4 4 4 4 4 4 3 3 5 3 5 4 4 5 3 3 4 4 3 4 4 3 4 4 5 5 4 3 4 4 5 4 3 5 4 5 4 4 4 5 5 3 4
34	Future	The use of precast concrete system will be increasing within the next 10 years.	5 4 3 3 2 4 2 5 5 4 5 4 5 4 4 3 4 5 3 4 3 4 5 3 3 4 4 4 4 5 3 5 5 4 4 4 4 3 4 5 2 2 5 3 4 4 3 4 5 5 5 4

CONTRACTORS RESPONSES																																										
	FACTOR	QUESTIONS	RESPONSES																																							
1	Demand for Large Housing Projects	As the demand of large housing projects increases, the need for precast concrete buildings increases.	3	1	2	4	4	5	4	4	5	5	5	3	3	2	5	5	4	4	4	4	5	4	5	3	5	4	5	5	3	3	4	4	3	2	5	4	4	3	5	1
2		It is preferred to use precast concrete system in large housing projects; where the buildings are standardized.	5	1	4	4	4	5	5	5	5	5	5	4	4	4	4	5	4	5	4	4	5	4	5	4	4	5	5	4	5	4	5	5	5	2	5	2	5	3	5	1
3		The precast concrete systems are widely used in Saudi Arabia.	4	2	4	4	4	1	3	5	5	4	4	4	4	3	5	4	3	3	4	2	3	4	5	4	4	3	5	4	4	1	3	3	3	3	4	3	4	4	3	4
4	Level of Standardization	The standard shapes and sizes of precast concrete elements restrict its broad use.	4	2	3	3	3	3	4	2	4	1	4	2	2	2	5	3	4	2	2	2	4	3	3	3	4	2	4	2	3	3	2	3	3	3	3	4	3	2	4	3
5		The use of precast concrete system is more preferred for multi-story (more than 5 stories) buildings.	4	1	2	4	3	2	3	3	3	2	2	2	2	2	4	2	4	3	3	5	3	4	4	2	4	2	2	3	2	1	1	3	3	1	2	3	4	4	1	1
6		Precast concrete manufacturers in Saudi Arabia have the same standard shapes and sizes of precast concrete elements.	2	2	3	2	2	2	4	4	2	2	2	2	2	2	4	2	4	4	4	2	3	4	3	3	1	2	4	4	1	3	1	4	3	3	2	4	4	3	4	1
7		Contractors and Consultants in Saudi Arabia prefer using the products of PCI-certified precast concrete manufacturers.	3	1	3	4	3	3	4	5	4	5	4	4	3	2	4	4	3	4	4	3	4	4	3	4	4	3	4	3	3	5	5	4	4	3	3	3	3	4	2	5
8	Experts	Consultants in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	2	3	4	3	4	2	3	4	3	4	1	4	4	2	5	4	4	3	3	4	3	4	4	4	4	4	4	3	3	3	2	3	3	4	3	4	3	4	4	3
9		Contractors in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	3	3	4	4	4	2	3	4	3	4	1	4	4	2	4	4	4	3	4	4	3	4	4	4	4	3	5	3	3	3	2	3	3	4	4	3	3	3	2	4
10		There are many contractors/subcontractors in Saudi Arabia who are experts in the erection of precast concrete systems.	2	2	4	4	3	2	4	4	3	4	4	4	2	2	4	4	3	4	3	3	3	4	3	4	4	3	5	4	5	3	5	4	3	3	4	3	3	3	2	5
11	Design Issues	Architectural creativity suffers when Precast concrete systems are used.	4	5	4	3	3	4	4	4	4	2	3	4	4	2	4	3	3	2	4	5	2	3	3	2	2	4	4	3	4	1	5	4	4	2	2	3	4	3	4	5
12		Structural capability is limited with the use of precast concrete system.	4	4	3	3	3	2	4	2	4	2	4	3	3	2	4	2	3	2	2	1	3	2	3	3	3	2	4	2	3	1	2	2	4	2	4	3	3	4	4	3
13		Precast concrete buildings are not suited to resist earthquake forces.	4	3	2	2	2	2	2	2	2	2	2	3	4	4	4	2	3	2	1	1	4	2	2	1	3	2	1	4	2	5	2	2	3	3	3	3	3	2	4	3
14		Precast concrete system is flexible with design changes at site (after erection).	2	2	1	3	3	1	2	1	2	4	1	2	4	3	4	4	2	1	2	1	2	3	4	2	4	3	4	2	1	1	2	2	2	3	3	3	4	2	1	1
15	Transportation	Transportation constraints limit the design of precast concrete elements in terms of shape and size.	5	3	1	3	3	4	4	4	4	2	5	2	4	5	5	4	4	4	1	3	3	4	3	2	2	4	4	3	3	3	5	4	3	3	4	2	3	4	4	4
16		It is easy to transport the precast concrete elements anywhere in the Kingdom.	2	4	5	4	3	3	4	4	4	4	4	5	3	4	5	2	1	2	4	2	2	4	5	3	3	2	5	3	5	2	2	2	2	2	4	3	3	2	4	3
17		In many cases, projects are delayed due to late delivery of the precast concrete elements.	1	3	4	4	2	5	4	2	2	3	4	3	4	2	5	1	2	4	2	2	4	4	2	2	2	4	4	4	3	4	5	4	3	3	4	3	3	4	4	4
18		The transportation cost is one of the main concerns for choosing the precast concrete system as a construction system.	4	4	4	4	3	2	4	3	4	4	4	2	5	2	5	2	2	4	4	4	4	4	2	2	4	2	5	4	2	2	3	3	3	2	4	2	3	3	5	5
19	Union regulation/rules	Labor ministry regulation/rules support the use of precast concrete system.	3	4	2	3	3	3	4	3	3	5	2	3	3	3	5	3	3	3	4	3	3	3	3	3	3	2	4	3	3	2	2	2	3	3	3	3	2	2	3	3
20	Communication among Parties	Consultants in Saudi Arabia involve the precast manufacturers at the early design stage of a precast concrete building.	4	4	2	4	4	3	4	3	3	4	4	2	3	2	5	4	4	3	3	3	4	4	2	4	4	4	3	2	4	3	4	4	4	2	3	3	3	2	4	1
21		Contractors in Saudi Arabia are purchasing from the same precast concrete manufacturers who were consulted at estimation/bidding stage.	2	2	2	4	3	4	3	2	2	3	2	2	4	4	4	2	4	4	2	4	3	2	3	3	3	4	3	3	2	3	2	2	4	3	3	3	3	3	4	1
22		Precast concrete manufacturers in Saudi Arabia are managing their production, transportation and erection activities in a professional way.	5	4	2	3	3	4	3	3	4	4	4	4	4	2	5	4	3	4	3	2	3	3	3	4	4	3	4	3	4	2	2	3	3	3	4	3	3	2	4	5
23		Precast concrete manufacturers communicate properly with consultants and contractors.	4	2	4	3	4	4	3	4	4	4	4	4	3	4	5	4	4	4	4	3	4	4	3	4	4	3	4	2	4	3	4	4	4	2	4	3	4	3	4	3
24		Precast concrete manufacturers are open to give the required Technical/Engineering support for contractors and consultants.	4	3	4	3	3	4	4	4	4	4	4	4	4	4	5	5	4	4	4	3	3	4	3	4	4	3	4	2	4	3	4	3	4	4	4	4	4	3	4	3
25	Cost Savings	The Cost of the precast concrete system is higher than the traditional construction system (for the same building).	3	4	4	4	4	4	4	4	2	4	5	5	4	5	5	2	3	3	2	2	4	3	3	3	2	3	5	3	5	1	5	5	5	2	3	2	2	4	4	3
26		Erection /crane cost negatively affect the use of precast concrete system.	4	2	5	3	2	5	4	3	4	3	4	4	4	4	5	2	3	4	3	2	4	3	3	3	3	3	5	2	5	1	2	4	5	2	3	4	2	4	4	3
27		The use of precast concrete system reduces the overall project cost. i.e. (engineering, materials, supervision, labor cost…etc).	3	4	3	2	2	4	2	4	2	4	2	2	3	2	5	4	4	3	2	4	3	4	3	4	3	3	4	2	3	2	5	3	3	3	4	2	3	4	4	3
28	User Satisfaction	Precast concrete buildings achieve occupant's satisfaction.	4	4	4	3	3	3	4	4	2	4	4	4	4	4	5	3	4	4	4	2	4	4	3	4	4	3	4	3	4	4	2	3	3	2	4	3	3	4	4	3
29	Buildability/ Constructability	Precast concrete system is easy and fast to be built /implement.	4	5	4	4	3	4	4	5	4	4	4	4	4	5	5	4	4	4	4	4	3	4	3	4	4	4	5	3	4	5	5	3	5	3	5	4	4	4	4	4
30		The execution of a precast concrete building involves less activities compared to the traditional system.	3	5	4	4	3	4	4	5	4	5	5	5	4	4	5	4	4	4	4	4	4	4	3	4	4	4	5	3	4	2	4	4	4	2	5	4	3	4	4	1
31	Quality	Precast concrete system can reach to a quality level that cannot be reached using traditional system.	5	4	4	4	4	4	4	2	4	4	4	3	5	4	5	5	4	5	4	4	3	3	3	4	4	4	5	4	2	5	5	3	5	3	4	3	3	4	3	2
32	Speed of erection	The use of precast concrete system reduces the project construction time.	4	5	2	5	4	5	4	4	5	5	4	4	5	5	5	4	4	5	4	4	3	4	3	4	4	4	5	3	4	5	5	2	5	2	5	3	4	4	4	4
33	Environment	Precast concrete system is environment-friendly.	4	4	3	5	5	3	4	5	4	5	4	3	4	3	5	4	4	3	4	3	3	4	4	5	4	3	5	4	3	3	5	3	3	3	5	3	4	3	5	4
34	Future	The use of precast concrete system will be increasing within the next 10 years.	4	5	3	5	3	5	4	3	4	5	4	4	3	4	5	4	4	4	4	3	4	4	5	3	3	4	5	5	3	4	5	4	3	3	5	4	3	3	5	1

PRECAST MANUFACTURERS RESPONSES

	FACTOR	QUESTIONS	RESPONSES																														
1	Demand for Large Housing Projects	As the demand of large housing projects increases, the need for precast concrete buildings increases.	4	4	5	4	5	4	5	2	5	3	4	4	5	4	3	5	5	4	3	2	5	4	3	5	5	4	5	5	4	5	5
2		It is preferred to use precast concrete system in large housing projects; where the buildings are standardized.	5	4	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	4
3		The precast concrete systems are widely used in Saudi Arabia.	4	5	4	4	5	3	3	4	5	3	5	5	4	3	3	5	2	4	3	4	5	4	4	5	4	5	5	4	4	3	4
4	Level of Standardization	The standard shapes and sizes of precast concrete elements restrict its broad use.	2	2	4	4	5	3	3	3	1	2	2	5	3	3	2	1	2	3	4	4	4	3	2	1	3	2	5	4	1	4	4
5		The use of precast concrete system is more preferred for multi-story (more than 5 stories) buildings.	2	3	2	4	2	2	2	3	3	2	5	2	2	3	1	1	2	3	2	3	5	3	2	5	5	2	5	3	2	5	3
6		Precast concrete manufacturers in Saudi Arabia have the same standard shapes and sizes of precast concrete elements.	2	2	1	3	2	3	3	4	3	4	1	1	4	2	3	3	3	2	4	2	5	5	2	5	1	2	5	3	3	4	4
7		Contractors and Consultants in Saudi Arabia prefer using the products of PCI-certified precast concrete manufacturers.	2	1	2	4	5	4	2	4	1	3	1	3	5	5	4	3	2	4	2	4	5	3	1	5	1	5	5	4	1	5	4
8	Experts	Consultants in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	3	2	4	2	2	2	1	3	1	2	1	4	2	2	3	3	2	4	1	2	5	3	2	5	2	2	5	4	4	5	3
9		Contractors in Saudi Arabia have adequate Technical/Engineering experience in precast concrete systems.	3	3	3	3	2	4	2	4	2	3	1	4	4	4	2	3	3	3	1	2	5	4	3	5	4	4	5	4	4	5	3
10		There are many contractors/subcontractors in Saudi Arabia who are experts in the erection of precast concrete systems.	2	1	2	3	3	3	2	4	1	3	1	4	2	3	1	4	4	3	2	4	5	3	2	5	3	2	5	3	5	5	3
11	Design Issues	Architectural creativity suffers when Precast concrete systems are used.	2	1	4	2	1	3	2	4	1	4	2	2	4	3	3	2	2	4	4	3	1	2	2	5	4	2	5	1	1	1	2
12		Structural capability is limited with the use of precast concrete system.	2	1	1	2	2	2	1	1	1	3	1	1	4	2	1	2	1	2	2	2	1	2	2	5	4	1	5	2	1	5	2
13		Precast concrete buildings are not suited to resist earthquake forces.	1	1	2	2	1	2	2	1	2	2	1	2	2	1	1	2	1	2	2	2	4	1	1	5	1	2	5	1	1	5	2
14		Precast concrete system is flexible with design changes at site (after erection).	3	1	2	4	5	3	3	2	3	3	1	2	4	2	1	3	3	3	4	5	4	2	3	5	2	4	5	2	4	5	3
15	Transportation	Transportation constraints limit the design of precast concrete elements in terms of shape and size.	3	3	4	2	5	4	3	5	4	3	5	2	4	4	5	4	4	3	4	3	4	4	4	5	5	2	5	4	2	5	3
16		It is easy to transport the precast concrete elements anywhere in the Kingdom.	4	5	5	4	4	4	4	3	3	4	3	4	5	2	4	4	5	4	4	5	5	4	2	5	5	5	5	5	5	5	4
17		In many cases, projects are delayed due to late delivery of the precast concrete elements.	2	1	2	2	2	2	2	1	1	2	1	1	3	2	2	3	1	2	2	5	1	1	2	5	1	1	5	1	2	5	2
18		The transportation cost is one of the main concerns for choosing the precast concrete system as a construction system.	3	1	1	2	2	3	2	4	1	4	5	3	2	3	1	3	2	4	2	5	4	2	4	5	3	5	5	5	3	5	3
19	Union regulation/rules	Labor ministry regulation/rules support the use of precast concrete system.	3	3	3	5	5	3	3	3	3	4	4	3	2	2	3	3	2	3	3	4	5	3	3	5	2	5	5	4	4	5	3
20	Communication among Parties	Consultants in Saudi Arabia involve the precast manufacturers at the early design stage of a precast concrete building.	4	2	3	4	4	4	2	4	2	2	2	3	2	1	4	4	2	4	1	4	5	3	2	5	3	5	5	5	5	5	4
21		Contractors in Saudi Arabia are purchasing from the same precast concrete manufacturers who were consulted at estimation/bidding stage.	4	1	2	3	2	4	3	4	3	2	1	4	4	2	2	3	1	3	2	3	3	4	3	5	2	4	5	4	2	1	2
22		Precast concrete manufacturers in Saudi Arabia are managing their production, transportation and erection activities in a professional way.	4	4	3	3	5	4	4	4	4	4	4	4	5	4	4	3	5	4	4	3	5	5	4	5	4	5	5	4	5	5	4
23		Precast concrete manufacturers communicate properly with consultants and contractors.	5	4	3	4	5	4	4	2	5	4	4	5	3	4	4	3	5	4	4	4	5	5	4	5	3	5	5	4	5	5	4
24		Precast concrete manufacturers are open to give the required Technical/Engineering support for contractors and consultants.	5	5	4	5	5	5	4	4	5	4	5	5	4	5	4	4	5	4	4	3	5	5	4	5	4	5	5	4	5	1	4
25	Cost Savings	The Cost of the precast concrete system is higher than the traditional construction system (for the same building).	3	5	5	2	2	4	2	4	2	2	5	4	4	3	5	4	2	4	3	4	1	2	4	5	5	5	5	2	3	4	2
26		Erection /crane cost negatively affect the use of precast concrete system.	3	3	4	2	4	3	2	5	1	2	4	4	2	4	5	4	1	4	2	4	3	2	3	5	3	5	5	3	2	5	2
27		The use of precast concrete system reduces the overall project cost. i.e. (engineering, materials, supervision, labor cost…etc).	5	4	3	4	5	4	5	3	5	3	1	3	5	3	1	4	5	3	3	5	5	4	3	5	3	1	5	4	3	5	4
28	User Satisfaction	Precast concrete buildings achieve occupant's satisfaction.	5	4	4	4	5	4	5	4	5	4	4	4	3	4	3	3	5	3	4	3	5	4	4	5	5	4	5	4	5	5	4
29	Buildability/ Constructability	Precast concrete system is easy and fast to be built /implement.	5	5	4	5	5	5	4	5	5	5	5	4	5	4	4	4	5	4	3	4	5	5	4	5	5	5	5	5	5	5	4
30		The execution of a precast concrete building involves less activities compared to the traditional system.	5	5	5	5	5	5	4	5	5	4	5	4	5	5	5	4	5	4	4	4	5	5	5	5	5	2	5	5	5	5	5
31	Quality	Precast concrete system can reach to a quality level that cannot be reached using traditional system.	5	4	4	5	5	5	4	5	5	4	5	3	4	5	5	5	5	3	4	4	1	4	5	1	5	4	5	4	5	5	5
32	Speed of erection	The use of precast concrete system reduces the project construction time.	5	5	4	5	5	5	5	5	5	4	5	4	5	5	5	5	5	4	4	4	5	5	4	5	5	5	5	5	5	5	5
33	Environment	Precast concrete system is environment-friendly.	5	4	5	5	5	5	5	5	5	4	5	4	4	4	3	4	5	4	4	5	5	5	4	5	5	5	5	3	5	5	5
34	Future	The use of precast concrete system will be increasing within the next 10 years.	5	3	3	5	5	4	5	5	4	4	5	4	5	4	2	5	4	4	3	4	5	5	3	5	3	3	5	5	5	5	3

Vitae

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Nationality : PALESTINIAN

Date of Birth : 11/30/1987

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Address : KSA-Khobar-Mobile: 0503004065

Academic Background :

- **M.Sc.** in Construction Engineering and Management from King Fahd University of Petroleum and Minerals, SA, (Graduation: 2017)
- **B.S.** degree in Engineering (Structural Engineering), King Fahd University of Petroleum & Minerals (KFUPM). "GPA: 3.61 out of 4.00" (Graduation: 2011)

Ahmad Mousa Alfarra

Senior Structural Engineer

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ahmad.alfarra@gmail.com
Birth Date: 30-11-1987
Martial Status: Single
Transferable Iqama

OBJECTIVE

To obtain a full time position as a Senior. Structural Engineer in a professional working environment in which I can utilize my knowledge and work side by side with professionals.

EDUCATION

M.S. degree in progress (Expected Graduation Date: 2016)
King Fahd University of Petroleum & Minerals (KFUPM)
Construction Engineering Management

B.S. degree 2011
King Fahd University of Petroleum & Minerals (KFUPM)
Engineering (Structural Engineering)
"GPA: 3.61 out of 4.00"

PROFESSIONAL EXPERIENCE

Senior. Structural Engineer Since Sep. 2013
Nesma & Partners Contracting
1. Substructures & Superstructures Design - calculation sheet.
2. Produce, revise and approve all types of drawings (IFC, Shop Drawings & B.B.S).
3. Revise and approve technical submittals.
4. Revise and evaluating sub-contractors quotation.
5. Guide and solve technical quires from the sites.
6. Supervise the work at site.
7. Follow-up with client and coordinate with sub-contractors.
8. Involve in evaluating PD, DD and FD drawings.

MAIN PROJECTS:
1. National Guard Health Affair - specialized hospitals in regions Riyadh-Jeddah-AlTaif- Alqassem. (8 billion SR)
2. Dirab air base for National Guard. (2 billion SR)
3. Mosque Re-location. (First of its kind in Middle East).

Structural Engineer Jan. 2013 to May 2013
Targets Consulting Engineering
1. Substructures/Superstructures Design.
2. Drawings (IFC & Shop Drawings).

MAIN PROJECTS:
1. AL-SURAI COMPLEX. (60 Million SR)

Structural Engineer Jan. 2011 to May 2013
Trainee (CO-OP) Structural Engineer FULL TIME Feb. 2010 to Jan. 2011
PRAINSA Saudi Arabia – Precast Manufacturing Company
1. Superstructures Design (Prstressed Precast).
2. Provide calculation sheet.
3. Follow-up with production and erection.
4. Produce, revise and approve all types of drawings (IFC, Shop Drawings & B.B.S).

MAIN PROJECTS:
1. LULU Hyper Market. (65 Million SR)
2. Rafha Power Station.
3. Makkah, Taif, Qassim and Taif Substation.

TECHNICAL & COMPUTATIONAL SKILLS

Structural Engineering (Major) | Structural Mechanics/Analysis | Reinforced Concrete Design | Steel Structural Design | Pre-stressed Concrete Design | Precast Concrete Design | Integrated Structural Design | Basics of (Architecture, HVAC, Electrical, Illumination, and Acoustics)

SAP | Etabs | STAAD PRO | SAFE | PowerConnect | PROKON | RCM ACI-Builder | PCA | CONCISE Beam | Section Builder | Peikko Designer | Hilti PROFIS Anchor | ADT & AutoCAD | Microsoft Excel (Excellent skills) | Microsoft (PowerPoint, Word)

PROJECTS WORKED ON

Projects budget are vary from 1.5 million up to 8 Billion SR

TYPE OF PROJECT

Residential | Commercial | Industrial | Health care facility | Military | Parking | Complex | Labs

RESPONSIBILITIES

- Substructures Design.
- Superstructures Design.
- Supervision.
- Drawings (IFC & Shop Drawings)
- Follow-up with client.
- Coordination meetings with client.
- Provide solutions for different problems.
- Follow-up with production and erection.
- Provide calculation sheet.

CONTRACTORS

- Mammoet
- SOMAC.
- Foster wheeler.
- Nesma and Partners
- VENICA.
- Saudi Services for Electro-Mechanic Works (SSEM).
- Al-Hadaf.

CLIENTS

- ARAMCO
- Saudi Arabia National Guard
- Saudi Electricity Company (SEC)
- Saudi Marine Forces
- Ma'aden
- Jacobs
- Dar Al Handasah
- Alsylami limited company
- Al-Sura'ai
- Perkins + Will
- Najran Cement Company.
- Ma'aden
- DOW
- KAUST

INTERNATIONAL CODES / STANDARDS

SBC | ACI-318 | ACI-315 | AISC | ASCE/SEI – 7 | EuroCodes | EN 1991-1-1 | EN 1992-1-1 | UBC | IBC | PCI Design Handbook | PCI Hollow Core Manual | SEC Standards | Partial of R.C&ARAMCO standards

TRAINING COURSES

but not limited to

Course	Institute	Date
Kirby Steel Building Solutions	Kirby Co	2014
Hilti Solutions	Hilti Co	2014
Bentley BIM	Bentley Co	2014
Bentley – softwares introduction	Bentley Co	2016

GIVEN COURSES

I provided the following courses

Course	Institute	Date
Structural engineering-basics	Mashoura consultant office	2016

LANGUAGES

Arabic (Native)

English: Excellent

REFERENCES

Available up on request

2